

190
ACC #8

Report

for
**Underground Storage Tank
Removal**

for
**SHELLER-GLOBE
Keokuk, Iowa Facility**

prepared for
Sheller-Globe

3200 Main Street
Keokuk, Iowa 52632

January 3, 1990

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IOWA SECTION



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RCRA RECORDS CENTER



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1.0 Background:

In October of 1989, Randolph & Associates was contracted by Sheller Globe Corporation to oversee and assist in the closure of the Keokuk facility's underground storage tank systems. The systems were to be closed and would not be replaced. The following is a report drafted for Sheller Globe. It summarizes the findings of Randolph & Associates regarding the undersigned system closure and the follow up investigation on site.

1.1 Site History:

According to available information, the Keokuk facility began operation in 1904. The site has been used for the manufacturing of rubber and related products for the period. The plant currently produces weather stripping for automobiles as well as related vinyl products.

The site is located off Rt. 218 on the west end of the town of Keokuk, Iowa. The use of the area around the facility is varied. To the east is a residential area. The facility is then bounded by commercial properties including hotels, service stations and restaurants. To the immediate south of the facility, on company property, is a moderately sized lake. A sketch of the surrounding area is included in Appendix A (fig. 1).

1.2 GEOLOGY, HYDROGEOLOGY, TOPOGRAPHY

A topographic map of the site area is included in Appendix A (fig. 2). The likely geology of the area consists of unconsolidated alluvia deposits containing numerous buried channel and alluvial aquifers overlying Mississippian Aquifer deposits. These channels act as drains to the major aquifers. The Mississippian and Devonian-Mississippian aquifers are extensively developed for both commercial and domestic use.

The unconsolidated overlying materials and their characteristics make groundwater contamination in this area a distinct threat. Extensive plume migration is feasible. Domestic wells in the area are likely tapped into the relatively shallow aquifers and as such, are subject to possible contamination.

A profile sketch of the likely stratigraphic detail of the site area is included in Appendix A (fig. 3).

1.3 Site Assessment:

The underground storage system was located to the immediate north of the chemical mixing and hazardous materials storage building. The chemical building lies to the south of the main plant buildings. An active railroad services the plant and the tracks run between the main plant and the chemical building (fig. 1.1).

The underground storage system consisted of five tanks and related piping. The tanks were arranged as shown in figure (1.2). The piping for the system consisted of a double run (one abandoned) of 2 inch pipe from the south end of the manufacturing facility to the tank cluster. Piping also ran from the chemical building to the cluster.

The following table illustrates the layout of the system.

Table 1.1

Tank	No.	Gallons	Year Placed	Material Stored	Construction	Last Used
1	6000		1980	Toluene	Steel	'89
2	300		1966	Hexane	Steel	'76
3	1500		1971	MEK*	Steel	'80
4	1500		1971	MEK*	Steel	'85
5	4000		1971	Methylene Chloride	Steel	'86

*Methyl Ethyl Ketone

2.0 Investigation

After a preliminary walk over of the site, excavation of the tanks began. The excavated soils were placed on plastic in an areas designated for temporary storage. As the excavation proceeded, strong product odors were noticeable. The tanks were excavated and removed in order from west to east. When the first tank was removed, visibly contaminated liquids became noticeable as they seeped into the excavation. The liquids were pumped from the excavation into an above ground tank for temporary storage. Samples of the liquid were taken for analytical evaluation. The liquids seeped into the excavation as each of the five tanks were removed and were continuously pumped as they appeared.

The following table documents the condition of each tank as they were removed:

Table 2.1

<u>Tank</u>	<u>No Gallons</u>	<u>Condition</u>	<u>Date Pulled</u>	<u>Comments</u>
<u>1</u>	6000	Corrosion, some pitting	10/12/89	Known Leaker
2	300	Heavy Corrosion Pitting, Leaking Visibly	10/12/89	Overall Poor Condition, Known Leaker

Table 2.1 (continued)

3	1500	Heavy Corrosion Pitting, liquids flowing from holes	10/12/89	Poor Condition, Known Heavy Leaker
4	1500	Some Corrosion little pitting, no visible holes	10/13/89	Good Overall Condition
5	4000	Little Corrosion No Visible Holes	10/13/89	Good Overall Condition

Pictures taken of the tanks to document their condition are presented in Appendix D.

2.1 Pipeline

An investigation of the piping system was performed by advancing soil borings at 20 feet intervals along the length of the pipeline. The borings were advanced to a depth 2 feet below the level of the pipes. An HNU reading was then taken through the auger. Two sets of pipes were found at the site. One had been abandoned in place prior to 1980 and was known to have been leaking.

The following table illustrates the HNU values recorded at each interval.

Table 2.2

Pipeline Investigation

<u>Boring</u>	<u>HNU</u>	<u>Comments</u>
(Starting from manufacturing building to tank excavation)	Reading in ppm	
1	N/A	Skipped too close to electric lines
2	525	Free product 3' gravel fill
> (Combined between R.R. Tracks)		strong odor
3		
4	N/A	Hit buried R.R. tie could not advance over 6"

Table 2.2 (continued)

5	20	Gravel and clay fill, change auger and rinse stopper
6	60	Gravel, clay fill 3" asphalt
7	160	4" concrete, gravel clay fill
8	225	"
9	400	"
10	65	"
11	72	"

2.2 Tank Cluster

Four-4 inch monitoring wells were installed on the site in the locations shown in figure 2.1. The wells were located and installed under the direction and supervision of the Shellar Globe Corporate environmental representative on site.

The diagrams detailing well construction are given in Appendix E. The borings were continuously sampled as they were advanced using a split spoon sampling device. As the borings were advanced, strong odors were noticeable coming from the auger stems.

One of the three wells (well no. 2), produced water immediately and samples were taken for later analytical evaluation.

A sample retrieved from the 16-18' depth level of well number 3 had a strong odor and a reading of 725 ppm recorded on the photoionization device. This depth was found to be synonymous with the previous ground surface, before fill was placed on the site.

3.0 Iowa Department of Natural Resources Summary of Regulations regarding underground storage.

3.1 Closure:

The procedure for closure of an underground system consists of the following:

Empty and clean tanks (remove all sludges and liquids), including the draining of all lines. A site assessment to determine the presence of contamination is then performed in accordance with Iowa D.N.R. regulations. In selecting sample types, locations and methods consideration is given to closure method (vapor, soil, or groundwater), nature of substance stored in system, and type and depth of back fill.

A report is to be submitted to DNR on methods of assessment including site plans, depth to bottom of tanks, sampling locations sample depth, analytical results, soil types, excavation depths, substances stored and the registration tag numbers.

When contaminated soils, contaminated groundwater or free product (liquid or vapor) is discovered, DNR is to be notified within 24 hours and corrective action begun.

3.2 Tank Disposal:

The removed tanks can be properly disposed of by reusing the tanks in a manner other than regulated a UST, disposal at a salvage operation or permitted sanitary landfill under special waste authorization.

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pages

permeability of the materials on site gives indication of extensive plume migration. Lab results from the sample retrieved at boring 3, 16-18' depth, showed extremely high levels of toluene contamination. Seepage onto the excavation showed high levels of contamination from several solvent constituents. It can therefore be assumed that contamination has traveled into a position that could affect groundwater quality in the area. Attached in Appendix C are copies of groundwater chemistry information for each of the chemical constituents found in quantity on the site.

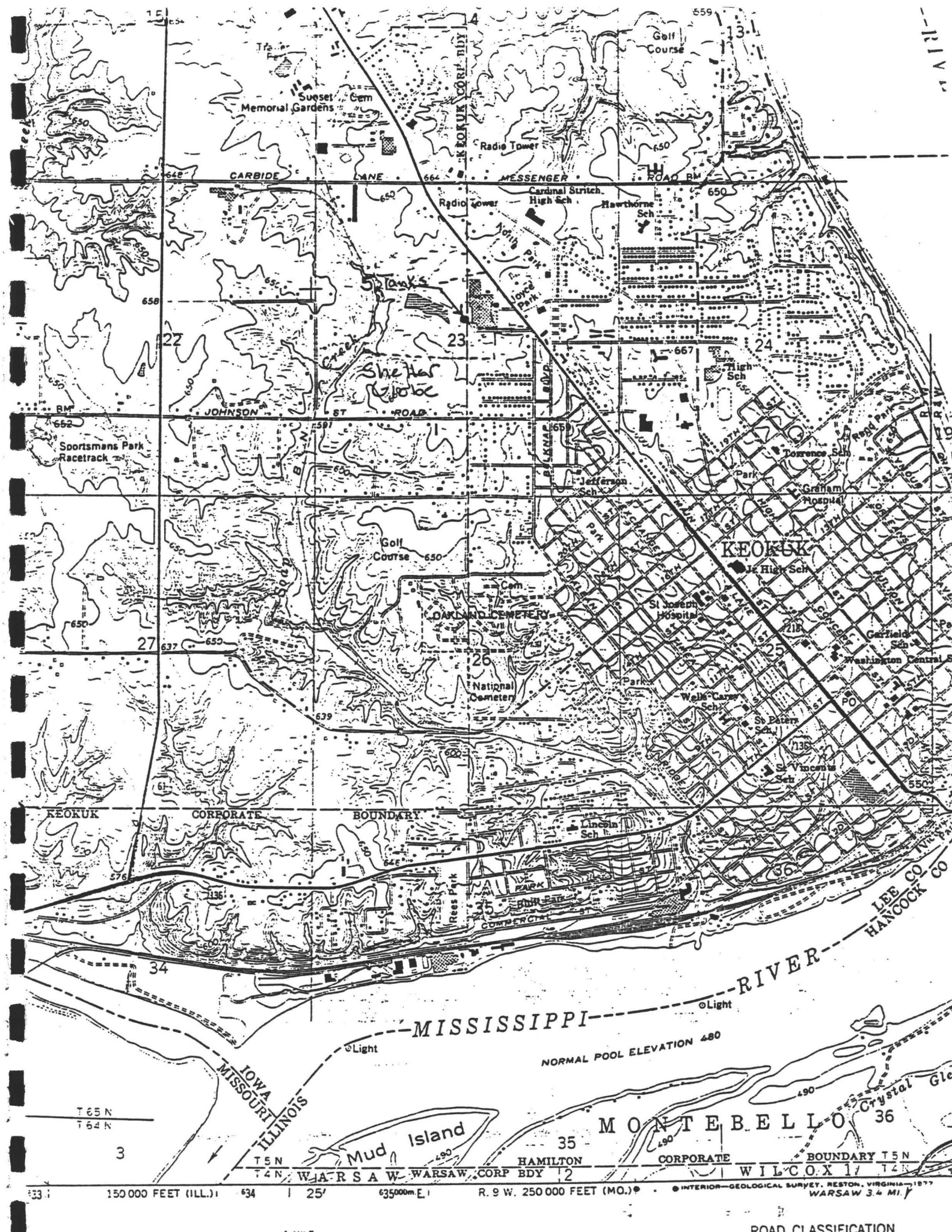
It is recommended that an in-depth investigation of the entire site be initiated as soon as practical to determine the extent of plume migration and to develop the required Corrective Action Plan (CAP). This investigation would entail soil borings, monitoring well installations, and laboratory analysis of samples recovered. All details of investigation planning and implementation must be submitted to and approved by Iowa D.N.R.

4.1 Follow Up Investigation

An in-depth investigation should be conducted on the Shellar-Globe site as soon as practical. The investigation would attempt to identify the extents of contaminate migration and the impacts on the local groundwater. A study of area groundwater use and the immediate possible impacts from the leakage would allow an analysis of any health threats.

APPENDIX A

SITE DIAGRAMS, HYDROGEOLOGIC AND TOPOGRAPHIC MAPS



150 000 FEET (ILL.)

635 000m E.

R. 9 W. 250 000 FEET (MO.)

INTERIOR-GEOLOGICAL SURVEY, RESTON, VIRGINIA-1977
WARSAW 3.4 MI. F

1 MILE

ROAD CLASSIFICATION

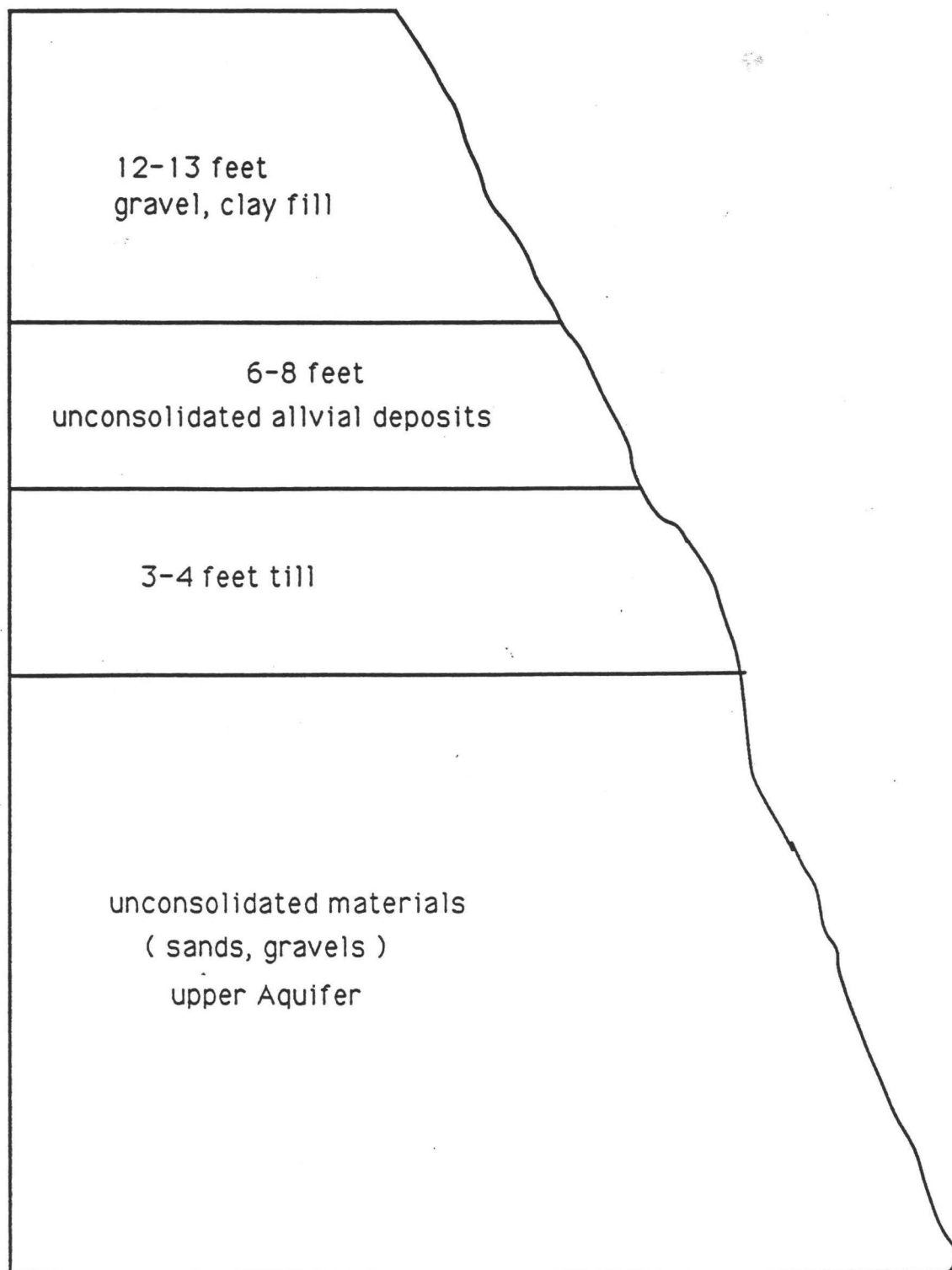


fig. A-3
Geologic Cross Section
Tank Area

BEDROCK AQUIFERS

The bedrock hydrogeologic map (fig.) shows the aquifers and aquicludes that make up the bedrock surface in southeastern Iowa. The Devonian aquifer is the first bedrock encountered in part of the northeastern corner of the area. The Mississippian aquifer lies beneath the surficial deposits in about one-half of the area. An aquiclude consisting of the Upper Devonian and lowest Mississippian rocks occur near the surface in the Mississippi River and Iowa River valleys. Pennsylvanian rocks comprise the bedrock surface in the

southwest and west, and outlying patches of Pennsylvanian are encountered over much of the area.

The Cambrian-Ordovician aquifer and the aquiclude which overlies it are not at the bedrock surface anywhere in southeastern Iowa. The Cambrian-Ordovician aquifer is quite deeply buried. Its location with respect to the other units is shown on figure . All the units are roughly parallel to each other and dip (slope) toward the southwest (fig.).

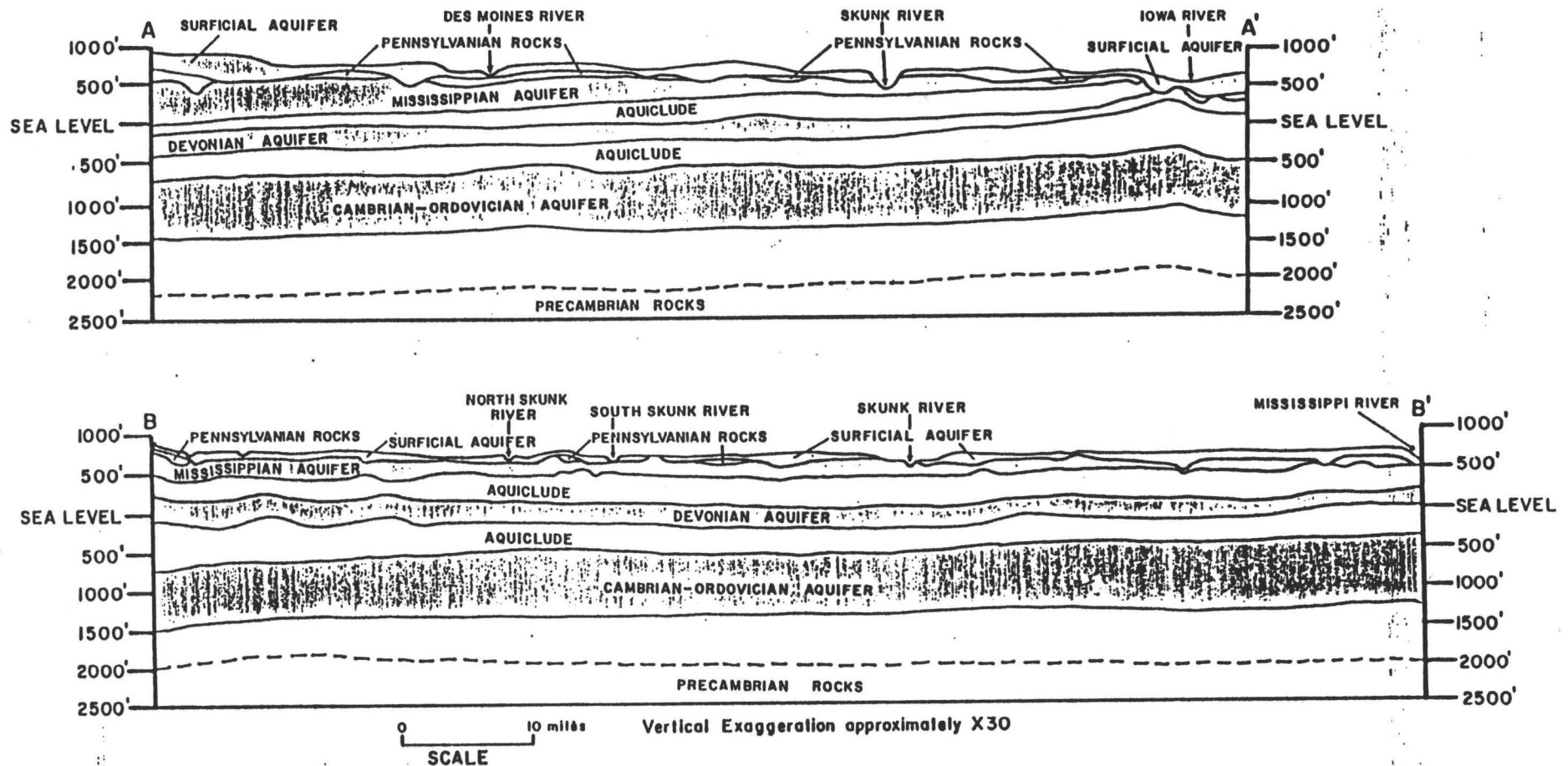


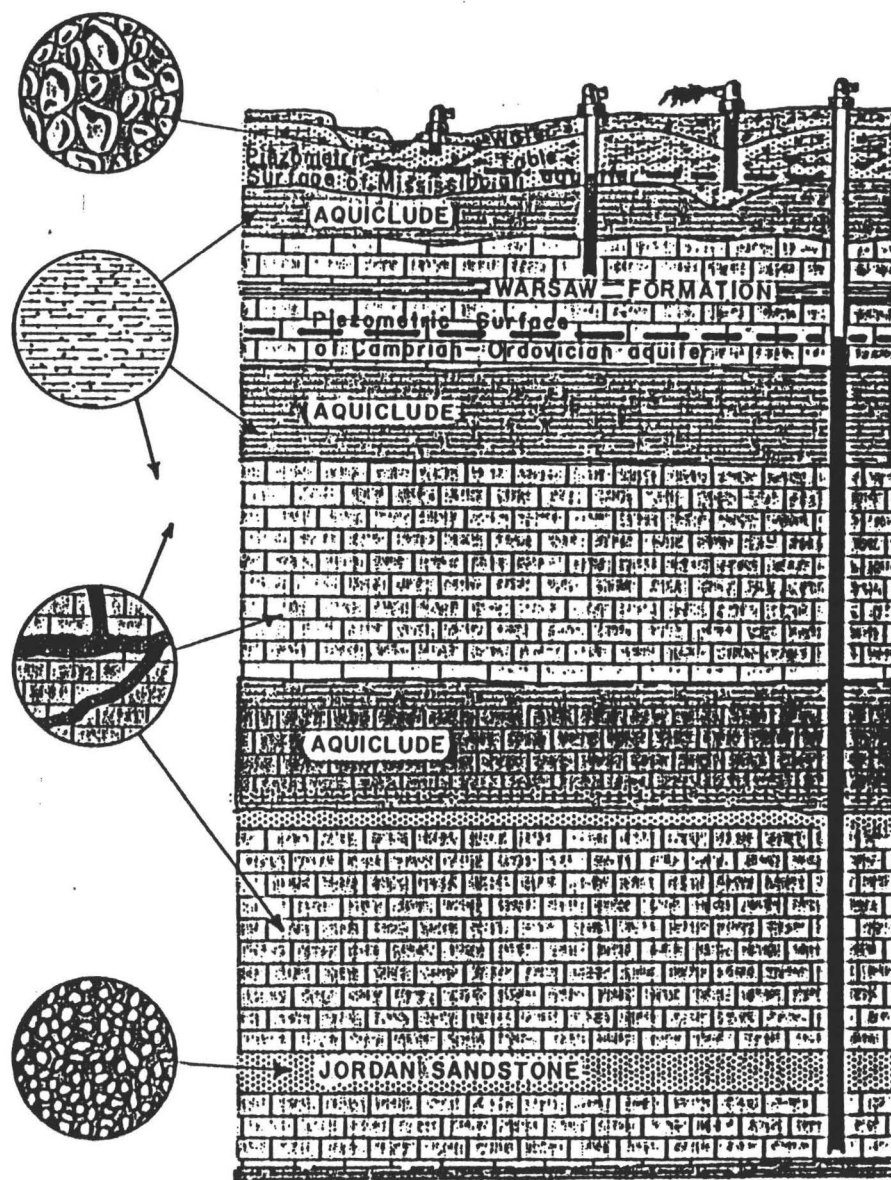
Figure —Hydrogeologic cross sections

Water is easily stored and flows freely in the open spaces between grains of sand or gravel.

Water is stored in large quantities in some aquicludes but, because the open spaces in the rocks are extremely small it is not transmitted readily.

Solution channels and fissures in limestone and dolomite are conduits in which ground water can move and be stored.

Water is stored and readily transmitted in the open spaces in sandstone.



SURFICIAL AQUIFERS

Gravels and sands are readily recharged by precipitation.

MISSISSIPPIAN AQUIFER

Water is easily replenished to this aquifer over a large part of southeast Iowa. However, the overlying aquiclude in other parts of the area retards recharge to the aquifer.

DEVONIAN AQUIFER

Local precipitation has little effect on water in this aquifer. Recharge occurs outside of this area and water moves laterally through the beds.

CAMBRIAN-ORDOVICIAN AQUIFER

Area of potential recharge more than 100 miles from southeast Iowa. Continued long-term withdrawals have resulted in lowered water levels over the entire area.

Figure —Occurrence of water in the aquifers

APPENDIX B

IOWA DEPARTMENT OF NATURAL RESOURCES

REGULATIONS REGARDING CLOSURE AND REPORTING OF CONTAMINATION

CHAPTER 132 TRANSPORTATION OF RADIOACTIVE MATERIALS IN IOWA

[Pm to 7:1 83, DEQ Ch 42]

[Prior to 3/86, Water, Air and Waste Management(WX)]

567—132.1(455B) Transportation of radioactive materials. All carriers of radioactive materials which are transported across the state of Iowa by highway and which are required to be labeled "Radioactive Yellow II" by the United States Department of Transportation in 49 CFR 172.403(d) must notify the state of Iowa prior to movement in Iowa in accordance with the rules of the Iowa Department of Transportation.

(Note: The Department of Transportation has not yet adopted those rules [on this subject]; so the notification requirement will not be effective until the Iowa Department of Transportation's rules are effective.)

This rule is in order to implement Iowa Code sections 455B.332 and 455B.333.

[Filed 9/26/80, Notice 4/16/80—published 10/15/80, effective 11/19/80]

[Filed 6/3/83, Notice 6/3/83—published 6/22/83, effective 7/1/83]

[Filed 1/14/86, Notice 1/14/86—published 12/3/86, effective 12/3/86]

CHAPTER 133 RULES FOR DETERMINING CLEANUP ACTIONS AND RESPONSIBLE PARTIES

567—133.1(455B) Scope.

133.1(1) These rules establish the procedures and criteria the department will use to determine the cleanup actions and responsible parties necessary to meet the goals of the state pertaining to the protection of the groundwater. These rules pertain to the cleanup of groundwater itself and to surface water where groundwater may be impacted. They may also be used as guidelines for other environmental protection activities authorized by Iowa Code chapter 455B. Where specific federal or state programs or funds exist to address situations that are addressed by these rules, the rules and standards of the specific programs or funds will be followed and utilized to achieve an equitable, expeditious and environmentally sound resolution of the particular contamination situation. These rules apply specifically to point source contamination only.

133.1(2) These rules apply specifically to cleanup actions required to abate, prevent or remove a hazardous condition, the presence of a hazardous substance or waste, the release of a regulated substance, or the discharge of a pollutant as those terms are defined in Iowa Code chapter 455B.

133.1(3) These rules shall not limit the department's authority to require remedial or preventative action, or to take remedial or preventative action, as necessary to protect the public health, the environment, or the quality of life. The department will make its evaluation on a case-by-case basis, considering site characteristics, and where more than one contaminant is present or there is no established action level, will consider the toxicity, mobility and persistence of contaminants involved. The evaluation may include the potential synergistic, antagonistic, or cumulative effects of the contaminants involved in a particular case.

133.1(4) Persons subject to these rules retain all applicable appeal rights provided in Iowa Code chapter 455B.

567—133.2(455B,455E) Definitions.

"Action level" means, for any contaminant, the HAL, if one exists; if there is no HAL, then the NRL, if one exists; if there is no HAL or NRL, then the MCL. If there is no HAL.

NRL, or MCL, an action level may be established by the department based on current technical literature and recommended guidelines of EPA and recognized experts, on a case-by-case basis.

"Active cleanup" means removal, treatment, or isolation of a contaminant from ground-water or associated environment through the directed efforts of humans.

"Aggravated risk" means a contamination situation which presents a potentially catastrophic or an immediate and substantial risk of harm to human life or health or to the environment. Examples include exposure of humans, animals or the food chain to acutely toxic substances, contamination of a drinking water supply, threat of fire or explosion, or similar situations.

"Background" means groundwater quality unaffected by human activities, and generally shall be determined by historical data of the geological services bureau or other government agencies for the type of aquifer or location involved in a given case. If available data is not adequate, background may be established by groundwater samples upgradient of a source or potential source of a substance which is detected in or has a reasonable probability of entering the groundwater.

"Best available technology" means those processes which most effectively remove, treat, or isolate contaminants from groundwater or associated environment, as determined through professional judgment considering actual equipment or techniques currently in use, published technical articles and research results, engineering reference materials, consultation with known experts in the field, and guidelines or rules of other regulatory agencies.

"Best management practices" means maintenance procedures, schedules of activities, prohibition of practices, and other management practices, or a combination thereof, which, after problem assessment and evaluation of alternatives is determined to be the most effective means of preventing or abating contamination at a location.

"Contaminant" means any chemical, ion, radionuclide, synthetic organic compound, microorganism, waste or other substance which does not occur naturally in groundwater or which occurs naturally at a lower concentration, and includes all hazardous substances as defined in 42 U.S.C. 9601, and any element, compound, mixture, solution or substance designated pursuant to 40 CFR 302.4 as of September 13, 1988.

"Groundwater" means any water of the state as defined in Iowa Code section 455B.171 which occurs beneath the surface of the earth in a saturated geologic formation of rock or soil.

"HAL" means a lifetime health advisory level for a contaminant, established by the United States Environmental Protection Agency (EPA). Health advisories represent the concentration of a single contaminant, based on current toxicological information, in drinking water which is not expected to cause adverse health effects over lifetime exposure.

"MCL" means the enforceable maximum contaminant level established by the EPA pursuant to the Safe Drinking Water Act.

"NRL" means the negligible risk level for carcinogens established by the EPA, which is an estimate of one additional cancer case per million people exposed over a lifetime to the contaminant (1×10^{-6}).

"Passive cleanup" means the removal or treatment of a contaminant in groundwater, or associated environment, through management practices or the construction of barriers, trenches and other similar facilities for prevention of contamination, as well as the use of natural processes such as groundwater recharge, natural decay and chemical or biological decomposition.

"Point source" means any building, structure, installation, equipment, pipe or pipeline (including any pipe into a sewer or publicly owned treatment works), well, pit, pond, lagoon, impoundment, ditch, landfill, storage container, motor vehicle, rolling stock, or aircraft, or any site or area where a contaminant has been deposited, stored, disposed of, or placed, or otherwise come to be located.

"Preventative" or *"prevention"* refers, in the context of these rules, to actions or efforts to minimize or stop further contamination in a situation where contamination already exists or is imminent.

"Remedial action plan" means a written report which includes all relevant information, findings, and conclusions from a site assessment, including all analytical results and identification of contaminant migration pathways; identification and evaluation of cleanup alternatives, including both active and passive measures using best available technology and best management practices; a recommended cleanup action or combination of action, including identification of expected cleanup levels consistent with the cleanup goal of 133.4(3)"h"; a monitoring network and schedule to document cleanup levels; and a proposed schedule of implementation.

"Responsible person" means any person who is legally liable for the contamination in question or who is legally responsible for abating contamination under any applicable law, including Iowa Code chapters 455B and 455E, and the common law. This may include the person causing, allowing or otherwise participating in the activities or events which cause the contamination, persons who have failed to conduct their activities so as to prevent the release of contaminants into groundwater, property owners who are obligated to abate a condition, or persons responsible for or successor to such persons.

"Significant risk" means:

1. The presence in groundwater of a contaminant in excess of an action level;
2. The presence of a contaminant in the soils, surface water, or other environment in proximity to groundwater which may reasonably be expected to contaminate the groundwater to an action level; or
3. The presence of a contaminant or contaminants in the groundwater, or in the soils, surface water or other environment in proximity of groundwater which may be expected to contaminate groundwater in quantities, concentrations, or combinations which may significantly adversely impact the public health, safety, environment, or quality of life. This criterion would normally be applied where there is no established action level or where combinations of more than one contaminant are present.

"Site assessment plan" means a written proposal for study of a contamination situation to determine the types, amounts, and sources of contaminants present, hydrogeological characteristics of the site, and the vertical and horizontal extent of contamination, with a goal of developing an adequate remedial action plan. The proposal must include: recommendations for collection of relevant historical data such as site management practices, inventory records, literature searches, photographs and personal interviews; a methodology for obtaining groundwater flow information including well placements, construction and elevation, bore logs, static groundwater table measurements, groundwater elevations, groundwater gradients (isopleth), and information on soil transmissivity, porosity and permeability; and a methodology for identifying contaminant plumes, including additional monitoring wells to identify the horizontal and vertical extent of contamination, a site plot showing the estimated configuration of contamination, and a sampling schedule and list of constituents to be analyzed. The plan development may require preliminary field investigations.

567—133.3(455B,455E) Documentation of contamination and source.

133.3(1) Sampling and analytical procedures. Unless rules for specific programs under USEPA or department authority provide otherwise, or unless other methods are approved by the department for a specific situation, samples taken and analyses made to document contamination or cleanup levels under this chapter shall be conducted in accordance with the following:

a. Samples. "A Compendium of Superfund Field Operations Methods," USEPA, Office of Emergency and Remedial Response, Washington, D.C. 20460 (EPA/540/P-87/001, OSWER Directive 93.55.0-14, December, 1987).

b. Analyses. "Test Methods for Evaluation of Solid Waste, Physical-Chemical Methods (SW-846)," USEPA, Third Edition, November 1986, as revised through December 1988. Until the department adopts rules regarding certification of laboratories, analyses shall be conduct-

at a laboratory that certifies to the department that the appropriate analytical procedure is utilized, or a laboratory which has been approved under EPA's Contract Laboratory Program. Upon adoption of rules by the department regarding certification of laboratories, all analyses shall be made at a certified laboratory. The parties, both the department and person responsible for investigating, shall have the opportunity to split samples for independent analysis, and where appropriate a sample portion shall be retained for a reasonable period of time for possible reanalysis.

133.3(2) Department determination of contamination. When the department receives or obtains evidence of groundwater contamination or the release or presence of contaminants in the environment associated with groundwater, where contamination of the groundwater may reasonably be expected, the department shall make reasonable efforts to document the source of contamination, and shall require responsible persons to take appropriate preventative, investigatory and remedial actions. Evidence of contamination may include but is not limited to the following:

- a. Water samples indicating the presence of a contaminant at levels above background.
- b. Soil or surface water samples indicating the presence of a contaminant at levels above background, where release to the groundwater is likely.
- c. Known releases of contaminants into the environment in quantities and locations that could reasonably be expected to cause groundwater contamination.
- d. Other events that the department determines could potentially cause groundwater contamination.

The amount and type of evidence necessary to document contamination or potential contamination will vary with the circumstances of each case, including the amount and type of contaminant involved, site topography and geologic conditions, and potential adverse effects. Normally, a reasonable number of water and soil samples will be taken or analyses obtained by the department. However, where a significant quantity of contaminants is known to have been released into the environment, for example from a spill, which could reach groundwater, the department is not required to collect samples.

133.3(3) Department determination of source. The department shall determine whether the contamination is or likely was caused by a particular source or sources, for example a known spill of contaminants or current or past facilities or activities in the vicinity which involved products or substances which could be a likely source. If no such person or event can be identified, the department shall make reasonable efforts to determine whether there is a relatively restricted area of more concentrated contaminants in the vicinity which is or is likely to be a source of the contamination. This subrule does not require the department to identify a specific person or persons responsible for the contamination, but to determine whether the contamination has or has likely come from a relatively defined source.

133.3(4) Determination of responsible persons. Where a source or likely source of contamination is identified, the person or persons responsible for that source or sources shall conduct necessary preventative, investigatory and remedial actions.

a. Identification. The persons responsible or potentially responsible initially shall be identified by the department through such measures as on-site observations; interviews with witnesses and local officials; review of public records, including department files; and interviews with or information obtained from potentially responsible persons. Where there may be more than one source, or the source is otherwise not conclusively identified, persons who handle or have handled materials or wastes in the vicinity of the contamination, which could be the source, shall investigate and provide information satisfactory to the department to confirm or disaffirm that their activities are a source of the contamination. Investigation by the responsible or potentially responsible person may include inspection of inventory or other records, and soil and groundwater monitoring to better define the source. Such monitoring shall conform to the requirements of 133.4(3)"a," provided that a full-scale assessment may not be required for this purpose.

b. Notification. The department shall notify in writing the persons determined responsible under the above procedures, and include a brief statement of the facts upon which the department concluded that they are responsible, and the actions required; provided that where immediate action is necessary, verbal notification may be given, followed up with written notification. The persons notified may provide information disputing or supplementing the information relied on by the department, which shall be considered by the department.

c. Responsible persons may be jointly and severally liable, and the department is not required to name all potentially responsible parties in directing responsive actions to contamination.

567—133.4(455B,455E) Response to contamination.

133.4(1) *Prevention of further contamination.* In all cases where an active source of contamination is identified, such as leaking tanks or current practices, which may be readily corrected, the source shall be removed, repaired or otherwise contained, or the contaminating practices ceased, immediately upon discovery of the source. In addition, readily accessible contaminants, for example concentrated contaminants spilled on the ground or accessible through a recovery well or system, shall be promptly removed to avoid or minimize further contamination in the groundwater.

133.4(2) *Aggravated risk.* Where the contamination presents an aggravated risk, the preventive, investigatory and remedial measures provided in subrules 133.4(1) and 133.4(3) shall be expedited to remove such risk. In addition, the following actions shall be taken by the responsible parties, if necessary, to protect the public health or environment:

- a. Providing alternate water supplies.
- b. Installing security fencing or other measures to limit access.
- c. Extraordinary measures to control the source of release.
- d. Removal of hazardous substances to an approved site for storage, treatment or disposal.
- e. Placing physical barriers to deter the spread of the release.
- f. Recommending to appropriate authorities the evacuation of threatened individuals.
- g. Using other materials to restrain the spread of the contaminant or to mitigate its effects.
- h. Executing damage control or salvage operations.

133.4(3) *Significant risk.* In cases of significant risk, the following investigatory and remedial measures shall be implemented:

a. *Investigation.* The responsible party shall determine the extent and levels of contamination through a site assessment conducted under the supervision of a registered professional engineer, an expert in the field of hydrogeology, or other qualified person. A site assessment plan shall be submitted to the department within 45 days of notice by the department, unless a shorter time is required or a longer time is authorized by the department. The plan shall be approved by the department prior to initiation of the assessment, unless otherwise approved by the department. The site assessment shall be conducted within a reasonable time and a remedial action plan shall be submitted to the department, within the time directed or approved by the department. The department may require further investigation by the responsible person in order to adequately assess the extent of contamination, and may require the remedial action plan to be supplemented if necessary.

b. *Required cleanup actions.*

(1) Groundwater. The goal of groundwater cleanup is use of best available technology and best management practices as long as it is reasonable and practical to remove all contaminants, and in any event until water contamination remains below the action level for any contaminant, and the department determines that the contamination is not likely to increase and no longer presents a significant risk. Where site conditions and available technology are such that attainment of these goals would be impractical, the department may establish an alternative

cleanup level or levels, including such other conditions as will adequately protect the public health, safety, environment, and quality of life.

(2) *Other.* Where significant amounts of contaminants are documented as being present in the soils or other environment, such that groundwater contamination is occurring or is likely, active cleanup of the contaminated soils or other environment shall be implemented to the extent reasonable and necessary to prevent or minimize release to the groundwater; passive cleanup may be allowed in extraordinary circumstances.

133.4(4) *Other.* Where significant risk is not currently present, the responsible person may be required to monitor the groundwater and implement reasonable management or other preventative measures to minimize further contamination.

567—133.5(455B, 455E) Report to commission. Department actions taken pursuant to this chapter shall be reported to the commission.

This chapter is intended to implement Iowa Code section 455E.5(5) and Iowa Code chapter 455B, Division III, Part I and Division IV, Part 4.

[Filed 6/23/89, Notice 3/22/89—published 7/12/89, effective 8/16/89]

CHAPTER 134 Reserved

CHAPTER 135 TECHNICAL STANDARDS AND CORRECTIVE ACTION REQUIREMENTS FOR OWNERS AND OPERATORS OF UNDERGROUND STORAGE TANKS

[Prior to 12/3/84, Water, Air and Waste Management(900)]

567—135.1(455B) Authority, purpose and applicability.

135.1(1) *Authority.* Iowa Code chapter 455B, division IV, part 8, authorizes the department to regulate underground tanks used for storage of regulated substances, and to adopt rules relating to detection, prevention and correction of releases of regulated substances from such tanks, maintenance of financial responsibility by owners or operators of such tanks, new tank performance standards, notice and reporting requirements, and designation of regulated substances.

135.1(2) *Purpose.* The purpose of these rules is to protect the public health and safety and the natural resources of Iowa by timely and appropriate detection, prevention and correction of releases of regulated substances from underground storage tanks (UST).

135.1(3) Applicability

a. The requirements of this chapter apply to all owners and operators of a UST system as defined in 135.2(455B) except as otherwise provided in paragraphs "b," "c," and "d" of this subrule. Any UST system listed in paragraph "c" of this subrule must meet the requirements of 135.1(4).

b. The following UST systems are excluded from the requirements of this chapter:

(1) Any UST system holding hazardous wastes listed or identified under Subtitle C of the Solid Waste Disposal Act, or a mixture of such hazardous waste and other regulated substances.

(2) Any wastewater treatment tank system that is part of a wastewater treatment facility regulated under Section 402 or 307(b) of the federal Clean Water Act.

(3) Equipment or machinery that contains regulated substances for operational purposes such as hydraulic lift tanks and electrical equipment tanks.

(4) Any UST system whose capacity is 110 gallons or less.

(5) Any UST system that contains a de minimus concentration of regulated substances.

(6) Any emergency spill or overflow containment UST system that is expeditiously emptied after use.

c. *Deferrals.* Rules 135.3(455B), 135.4(455B), 135.5(455B), 135.6(455B) and 135.8(455B) do not apply to any of the following types of UST systems:

c. Written documentation of all calibration, maintenance, and repair of release detection equipment permanently located on-site must be maintained for at least one year after the servicing work is completed, or for another reasonable time period determined by the department. Any schedules of required calibration and maintenance provided by the release detection equipment manufacturer must be retained for five years from the date of installation.

567—135.6(455B) Release reporting, investigation, and confirmation.

135.6(1) Reporting of suspected releases. Owners and operators of UST systems must report to the department within 24 hours, or within 6 hours in accordance with 567—Chapter 131 if a hazardous condition exists as defined in 567—131.1(455B), or another reasonable time period specified by the department, and follow the procedures in 135.6(3) for any of the following conditions:

a. The discovery by owners and operators or other of released regulated substances at the UST site or in the surrounding area (such as the presence of free product or vapors in soils, basements, sewer and utility lines, and nearby surface water).

b. Unusual operating conditions observed by owners and operators (such as the erratic behavior of product dispensing equipment, the sudden loss of product from the UST system, or an unexplained presence of water in the tank), unless system equipment is found to be defective but not leaking, and is immediately repaired or replaced; and

c. Monitoring results from a release detection method required under 135.5(2) and 135.5(3) that indicate a release may have occurred unless:

(1) The monitoring device is found to be defective, and is immediately repaired, recalibrated or replaced, and additional monitoring does not confirm the initial result; or

(2) In the case of inventory control, a second month of data does not confirm the initial result.

135.6(2) Investigation due to off-site impacts. When required by the department, owners and operators of UST systems must follow the procedures in 135.6(3) to determine if the UST system is the source of off-site impacts. These impacts include the discovery of regulated substances (such as the presence of free product or vapors in soils, basements, sewer and utility lines, and nearby surface and drinking waters) that has been observed by the department or brought to its attention by another party.

135.6(3) Release investigation and confirmation steps. Unless corrective action is initiated in accordance with rule 135.7(455B), owners and operators must immediately investigate and confirm all suspected releases of regulated substances requiring reporting under 135.6(1) within seven days, or another reasonable time period specified by the department, using either the following steps or another procedure approved by the department:

a. **System test.** Owners and operators must conduct tests (according to the requirements for tightness testing in 135.5(4) "c" and 135.5(5) "b") that determine whether a leak exists in that portion of the tank that routinely contains product, or the attached delivery piping, or both.

(1) Owners and operators must repair, replace or upgrade the UST system, and begin corrective action in accordance with rule 135.7(455B) if the test results for the system, tank, or delivery piping indicate that a leak exists.

(2) Further investigation is not required if the test results for the system, tank, and delivery piping do not indicate that a leak exists and if environmental contamination is not the basis for suspecting a release.

(3) Owners and operators must conduct a site check as described in paragraph "b" of this subrule if the test results for the system, tank, and delivery piping do not indicate that a leak exists but environmental contamination is the basis for suspecting a release.

b. **Site check.** Owners and operators must measure for the presence of a release where contamination is most likely to be present at the UST site. In selecting sample types, sample locations, and measurement methods, owners and operators must consider the nature of the stored substance, the type of initial alarm or cause for suspicion, the type of backfill, the depth of groundwater, and other factors appropriate for identifying the presence and source of the release.

(1) If the test results for the excavation zone or the UST site indicate that a release has occurred, owners and operators must begin corrective action in accordance with rule 135.7(455B);

(2) If the test results for the excavation zone or the UST site do not indicate that a release has occurred, further investigation is not required.

135.6(4) Reporting and cleanup of spills and overfills.

a. Owners and operators of UST systems must contain and immediately clean up a spill or overfill and report to the department within 24 hours, or within 6 hours in accordance with 567—Chapter 131 if a hazardous condition exists as defined in rule 567—131.1(455B), or another reasonable time period specified by the department, and begin corrective action in accordance with rule 135.7(455B) in the following cases:

(1) Spill or overfill of petroleum that results in a release to the environment that exceeds 25 gallons or another reasonable amount specified by the department, or that causes a sheen on nearby surface water; and

(2) Spill or overfill of a hazardous substance that results in a release to the environment that equals or exceeds its reportable quantity under CERCLA (40 CFR 302) as of September 13, 1988.

b. Owners and operators of UST systems must contain and immediately clean up a spill or overfill of petroleum that is less than 25 gallons or another reasonable amount specified by the department, and a spill or overfill of a hazardous substance that is less than the reportable quantity. If cleanup cannot be accomplished within 24 hours, or another reasonable time period established by the department, owners and operators must immediately notify the department.

NOTE: Any spill or overfill that results in a hazardous condition as defined in rule 131.1(455B) must be reported within 6 hours. A release of a hazardous substance equal to or in excess of its reportable quantity must also be reported immediately (rather than within 24 hours) to the National Response Center under sections 102 and 103 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and to appropriate state and local authorities under Title III of the Superfund Amendments and Reauthorization Act of 1986.

567—135.7(455B) Release response and corrective action for UST systems containing petroleum or hazardous substances.

135.7(1) *General.* Owners and operators of petroleum or hazardous substance UST systems must, in response to a confirmed release from the UST system, comply with the requirements of this rule except for USTs excluded under 135.1(3)“b” and UST systems subject to RCRA Subtitle C corrective action requirements under section 3004(u) of the Resource Conservation and Recovery Act, as amended.

135.7(2) *Initial response.* Upon confirmation of a release in accordance with 135.6(3) or after a release from the UST system is identified in any other manner, owners and operators must perform the following initial response actions within 24 hours of a release or within another reasonable period of time determined by the department:

a. Report the release to the department (e.g., by telephone or electronic mail);

b. Take immediate action to prevent any further release of the regulated substance into the environment; and

c. Identify and mitigate fire, explosion, and vapor hazards.

135.7(3) Initial abatement measures and site check.

a. Unless directed to do otherwise by the department, owners and operators must perform the following abatement measures:

(1) Remove as much of the regulated substance from the UST system as is necessary to prevent further release to the environment;

(2) Visually inspect any aboveground releases or exposed below-ground releases and prevent further migration of the released substance into surrounding soils and groundwater;

(3) Continue to monitor and mitigate any additional fire and safety hazards posed by vapors or free product that have migrated from the UST excavation zone and entered into subsurface structures (such as sewers or basements);

(4) Remedy hazards posed by contaminated soils that are excavated or exposed as a result of release confirmation, site investigation, abatement, or corrective action activities. If these remedies include treatment or disposal of soils, the owner and operator must comply with applicable state and local requirements;

(5) Measure for the presence of a release where contamination is most likely to be present at the UST site, unless the presence and source of the release have been confirmed in accordance with the site check required by 135.6(3)"b" or the closure site assessment of 135.8(3)"a." In selecting sample types, sample locations, and measurement methods, the owner and operator must consider the nature of the stored substance, the type of backfill, depth to groundwater and other factors as appropriate for identifying the presence and source of the release; and

(6) Investigate to determine the possible presence of free product, and begin free product removal as soon as practicable and in accordance with 135.7(5).

b. Within 20 days after release confirmation, or within another reasonable period of time determined by the department, owners and operators must submit a report to the department summarizing the initial abatement steps taken under paragraph "a" and any resulting information or data.

135.7(4) Initial site characterization.

a. Unless directed to do otherwise by the department, owners and operators must assemble information about the site and the nature of the release, including information gained while confirming the release or completing the initial abatement measures in 135.7(1) and 135.7(2). This information must include, but is not necessarily limited to the following:

(1) Data on the nature and estimated quantity of release;

(2) Data from available sources and site investigations concerning the following factors: surrounding populations, water quality, use and approximate locations of wells potentially affected by the release, subsurface soil conditions, locations of subsurface sewers, climatological conditions, and land use;

(3) Results of the site check required under 135.7(3)"a"(5); and

(4) Results of the free product investigations required under 135.7(3)"a"(6), to be used by owners and operators to determine whether free product must be recovered under 135.7(5).

b. Within 45 days of release confirmation or another reasonable period of time determined by the department, owners and operators must submit the information collected in compliance with paragraph "a" of this subrule to the department in a manner that demonstrates its applicability and technical adequacy, or in a format and according to the schedule required by the department.

135.7(5) Free product removal. At sites where investigations under 135.7(3)"a"(6) indicate the presence of free product, owners and operators must remove free product to the maximum extent practicable as determined by the department while continuing, as necessary, any actions initiated under 135.7(2) to 135.7(4), or preparing for actions required under 135.7(6) and 135.7(7). In meeting the requirements of this subrule, owners and operators must:

a. Conduct free product removal in a manner that minimizes the spread of contamination into previously uncontaminated zones by using recovery and disposal techniques appropriate to the hydrogeologic conditions at the site, and that properly treats, discharges or disposes of recovery by-products in compliance with applicable local, state and federal regulations;

b. Use abatement of free product migration as a minimum objective for the design of the free product removal system;

c. Handle any flammable products in a safe and competent manner to prevent fires or explosions; and

d. Unless directed to do otherwise by the department, prepare and submit to the department, within 45 days after confirming a release, a free product removal report that provides at least the following information:

- (1) The name of the person(s) responsible for implementing the free product removal measures;
- (2) The estimated quantity, type, and thickness of free product observed or measured in wells, boreholes, and excavations;
- (3) The type of free product recovery system used;
- (4) Whether any discharge will take place on-site or off-site during the recovery operation and where this discharge will be located;
- (5) The type of treatment applied to, and the effluent quality expected from, any discharge;
- (6) The steps that have been or are being taken to obtain necessary permits for any discharge and
- (7) The disposition of the recovered free product.

135.7(6) Investigations for soil and groundwater cleanup.

a. In order to determine the full extent and location of soils contaminated by the release and the presence and concentrations of dissolved product contamination in the groundwater, owners and operators must conduct investigations of the release, the release site, and the surrounding area possibly affected by the release if any of the following conditions exist:

- (1) There is evidence that groundwater wells have been affected by the release (e.g., as found during release confirmation or previous corrective action measures);
- (2) Free product is found to need recovery in compliance with 135.7(5);
- (3) There is evidence that contaminated soils may be in contact with groundwater (e.g., as found during conduct of the initial response measures or investigations required under 135.7(1) to 135.7(5); and
- (4) The department requests an investigation, based on the potential effects of contaminated soil or groundwater on nearby surface water and groundwater resources.

b. Owners and operators must submit the information collected under paragraph "a" of this subrule as soon as practicable or in accordance with a schedule established by the department.

135.7(7) Corrective action plan.

a. At any point after reviewing the information submitted in compliance with 135.7(2) to 135.7(4), the department may require owners and operators to submit additional information or to develop and submit a corrective action plan for responding to contaminated soils and groundwater. If a plan is required, owners and operators must submit the plan according to a schedule and format established by the department. Alternatively, owners and operators may, after fulfilling the requirements of 135.7(2) to 135.7(4), choose to submit a corrective action plan for responding to contaminated soil and groundwater. In either case, owners and operators are responsible for submitting a plan that provides for adequate protection of human health and the environment as determined by the department, and must modify their plan as necessary to meet this standard.

b. The department will approve the corrective action plan only after ensuring that implementation of the plan will adequately protect human health, safety, and the environment. In making this determination, the department should consider the following factors as appropriate:

- (1) The physical and chemical characteristics of the regulated substance, including its toxicity, persistence, and potential for migration;
- (2) The hydrogeologic characteristics of the facility and the surrounding area;
- (3) The proximity, quality, and current and future uses of nearby surface water and groundwater;
- (4) The potential effects of residual contamination on nearby surface water and groundwater;
- (5) An exposure assessment; and
- (6) Any information assembled in compliance with this rule.

c. Upon approval of the corrective action plan or as directed by the department, owners and operators must implement the plan, including modifications to the plan made by the department. They must monitor, evaluate, and report the results of implementing the plan in accordance with a schedule and in a format established by the department.

d. Owners and operators may, in the interest of minimizing environmental contamination and promoting more effective cleanup, begin cleanup of soil and groundwater before the corrective action plan is approved provided that they:

- (1) Notify the department of their intention to begin cleanup;
- (2) Comply with any conditions imposed by the department, including halting cleanup or mitigating adverse consequences from cleanup activities; and
- (3) Incorporate these self-initiated cleanup measures in the corrective action plan that is submitted to the department for approval.

135.7(8) Public participation.

a. For each confirmed release that requires a corrective action plan, the department must provide notice to the public by means designed to reach those members of the public directly affected by the release and the planned corrective action. This notice may include, but is not limited to, public notice in local newspapers, block advertisements, public service announcements, publication in a state register, letters to individual households, or personal contacts by field staff.

b. The department must ensure that site release information and decisions concerning the corrective action plan are made available to the public for inspection upon request.

c. Before approving a corrective action plan, the department may hold a public meeting to consider comments on the proposed corrective action plan if there is sufficient public interest, or for any other reason.

d. The department must give public notice that complies with paragraph "a" above if implementation of an approved corrective action plan does not achieve the established cleanup levels in the plan and termination of that plan is under consideration by the department.

567—135.8(455B) Out-of-service UST systems and closure.

135.8(1) Temporary closure.

a. When a UST system is temporarily closed, owners and operators must continue operation and maintenance of corrosion protection in accordance with 135.4(2), and any release detection in accordance with rule 135.5(455B). Rules 135.6(455B) and 135.7(455B) must be complied with if a release is suspected or confirmed. However, release detection is not required as long as the UST system is empty. The UST system is empty when all materials have been removed using commonly employed practices so that no more than 2.5 centimeters (one inch) of residue, or 0.3 percent by weight of the total capacity of the UST system, remain in the system.

b. When a UST system is temporarily closed for three months or more, owners and operators must also comply with the following requirements:

- (1) Leave vent lines open and functioning; and
- (2) Cap and secure all other lines, pumps, manways, and ancillary equipment.

c. When a UST system is temporarily closed for more than 12 months, owners and operators must permanently close the UST system if it does not meet either performance standards in 135.3(1) for new UST systems or the upgrading requirements in 135.3(2), except that the spill and overfill equipment requirements do not have to be met. Owners and operators must permanently close the substandard UST systems at the end of this 12-month period in accordance with 135.8(2) to 135.8(5), unless the department provides an extension of the 12-month temporary closure period. Owners and operators must complete a site assessment in accordance with 135.8(3) before such an extension can be applied for.

135.8(2) Permanent closure and changes-in-service.

a. At least 30 days before beginning either permanent closure or a change-in-service under paragraphs "b" and "c" below, or within another reasonable time period determined by the

department, owners and operators must notify the department of their intent to permanently close or make the change-in-service, unless such action is in response to corrective action. The required assessment of the excavation zone under 135.8(3) must be performed after notifying the department but before completion of the permanent closure or a change-in-service.

b. To permanently close a tank, owners and operators must empty and clean it by removing all liquids and accumulated sludges. All tanks taken out of service permanently must also be either removed from the ground or filled with an inert solid material.

c. Continued use of a UST system to store a nonregulated substance is considered a change-in-service. Before a change-in-service, owners and operators must empty and clean the tank by removing all liquid and accumulated sludge and conduct a site assessment in accordance with 135.8(3).

NOTE: The following cleaning and closure procedures may be used to comply with subrule 135.8(2): American Petroleum Institute Recommended Practice 1604, "Removal and Disposal of Used Underground Petroleum Storage Tanks"; American Petroleum Institute Publication 2015, "Cleaning Petroleum Storage Tanks"; American Petroleum Institute Recommended Practice 1631, "Interior Lining of Underground Storage Tanks," may be used as guidance for compliance with this subrule; and the National Institute for Occupational Safety and Health "Criteria for a Recommended Standard...Working in Confined Space" may be used as guidance for conducting safe closure procedures at some hazardous substance tanks.

135.8(3) Assessing the site at closure or change-in-service.

a. Before permanent closure or a change-in-service is completed, owners and operators must measure for the presence of a release where contamination is most likely to be present at the UST site. In selecting sample types, sample locations, and measurement methods, owners and operators must consider the method of closure, the nature of the stored substance, the type of backfill, the depth to groundwater, and other factors appropriate for identifying the presence of a release. The requirements of this subrule are satisfied if one of the external release detection methods allowed in 135.5(4)"e" and "f" is operating in accordance with the requirements in 135.5(4) at the time of closure, and indicates no release has occurred.

b. If contaminated soils, contaminated groundwater, or free product as a liquid or vapor is discovered under paragraph "a," or by any other manner, owners and operators must begin corrective action in accordance with rule 135.7(455B).

135.8(4) Applicability to previously closed UST systems. When directed by the department, the owner and operator of a UST system permanently closed before the effective date of these rules must assess the excavation zone and close the UST system in accordance with this rule if releases from the UST may, in the judgment of the department, pose a current or potential threat to human health and the environment.

135.8(5) Closure records. Owners and operators must maintain records in accordance with 135.4(5) that are capable of demonstrating compliance with closure requirements under this rule. The results of the excavation zone assessment required in 135.8(3) must be maintained for at least three years after completion of permanent closure or change-in-service in one of the following ways:

- a. By the owners and operators who took the UST system out of service;
- b. By the current owners and operators of the UST system site; or
- c. By mailing these records to the department if they cannot be maintained at the closed facility.

These rules are intended to implement Iowa Code chapter 455B.

- [Filed emergency 9/20/85—published 10/9/85, effective 9/20/85]
- [Filed emergency 11/14/86—published 12/3/86, effective 12/3/86]
- [Filed emergency 12/29/86—published 1/14/87, effective 1/14/87]
- [Filed 5/1/87, Notice 1/14/87—published 5/20/87, effective 7/15/87*]
- [Filed emergency 9/22/87—published 10/21/87, effective 9/22/87]
- [Filed 2/19/88, Notice 11/18/87—published 3/9/88, effective 4/13/88]
- [Filed emergency 10/24/88—published 11/16/88, effective 10/24/88]
- [Filed 7/21/89, Notice 2/22/89—published 8/9/89, effective 9/13/89]
- [Filed emergency 8/25/89—published 9/20/89, effective 8/25/89]

*Effective date of 135.9(4) delayed seventy days by administrative rules review committee at its June 1987 meeting.

UNDERGROUND TANK CLOSURE
FOR TANK OWNERS REMOVING TANKS USING
PORTABLE VAPOR ANALYSIS METHOD

This document provides underground storage tank owners with an acceptable method for performing an underground tank closure using a portable vapor analyzer. This document discusses the equipment and the procedures necessary to conduct the investigation, and the meaning of the investigation's results. NOTE THAT THE UNDERGROUND TANK OWNER MUST NOTIFY THIS DEPARTMENT IN WRITING OF PERMANENT TANK CLOSURE OR A CHANGE-IN-SERVICE* AT LEAST THIRTY (30) DAYS PRIOR TO THE CLOSURE OR SERVICE CHANGE.

Vapor Analysis Method

NOTE: These instruments have the following general limits:

1. Can only be used when the ambient temperature is above 40°F;
and
2. For volatile substances (e.g., gasoline, diesel)

Equipment Needed:

- Portable vapor analyzer (a description of some commonly used portable analyzers is attached)
- Auger tool large enough to accommodate vapor analysis equipment.

NOTE: Groundwater may be encountered while performing these procedures. In that event, you must analyze the groundwater for potential contamination according to the attached method.

Procedure:

1. Remove the underground tank and its connected piping in accordance with Subrule 135.8(2) of Chapter 135 of the Iowa Administrative Code (IAC).
2. Sampling shall be performed projecting the tank's dimensions on to the floor of the tank excavation. This projected area shall then be divided into equal areas of sixty (60) square feet as identified by the tank volume/sampling area chart in Diagram A attached. Sampling shall be performed in the center of each of these areas.
3. Sketch a dimensioned overview of the excavation area indicating the position of the sampling locations. Label each location accordingly.
4. Auger to a depth of at least three feet into the floor of the excavation at each sampling area. Remove the augering tool. Carefully lower the vapor analyzer and connected probe into the borehole making sure that the end of the probe does not touch the walls or the bottom of the borehole. The probe end must not be immersed in any standing water. Seal the area

around probe and the top of the borehole with aluminum foil to prevent the escape of volatile products.

5. Begin the analysis on the highest concentration scale possible, noting the response on the readout indicator. Adjust the concentration scale as necessary until a response on the readout indicator is observed.
6. Record the results obtained in parts per million (PPM) for each individual location. Retain a copy of these analysis results and the sampling location sketch at the facility for a minimum of three (3) years as required per Subrule 135.8(5) of Chapter 135 of the Iowa Administrative Code (IAC). Copies of the vapor analysis results and a copy of the sampling location sketch shall be sent to the department for review. The metal tank registration tag(s) shall also accompany the laboratory results and the sampling location sketch.

NOTE: Trenches that contained underground tank piping shall be sampled similarly as described in procedures 3 through 5 above. The pipeline excavation shall be sampled every 10 lineal feet of piping.

* Change-in-service is defined as the continued use of an underground tank to store a non-regulated substance.

MEANING OF RESULTS

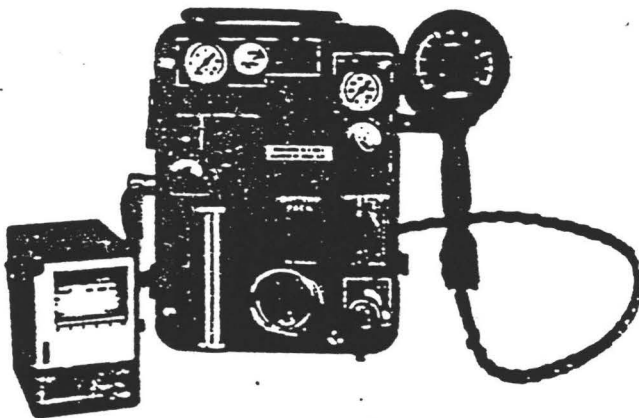
<u>Vapor Analyzer (parts per Reading million (PPM))</u>	<u>Action Required</u>
0-10	No action required at this time
Greater than 10	Contact the department at 515/281-8693

A:JH1

VAPOR MONITORING EQUIPMENT

Illustrated here are examples of portable instruments commonly used for the analysis of volatile substances. An important limitation to consider when assessing the use of these instruments is that the ambient air temperature cannot be below 40°F. The department does not endorse the use of any these instruments specifically, other similar instruments which provide equal monitoring capability may be available.

FLAME IONIZATION DETECTOR



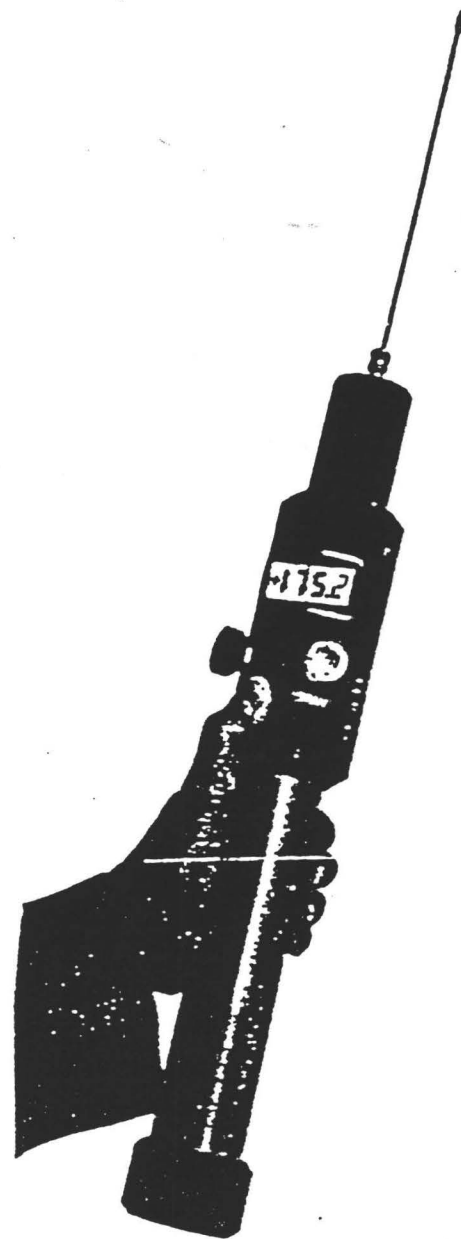
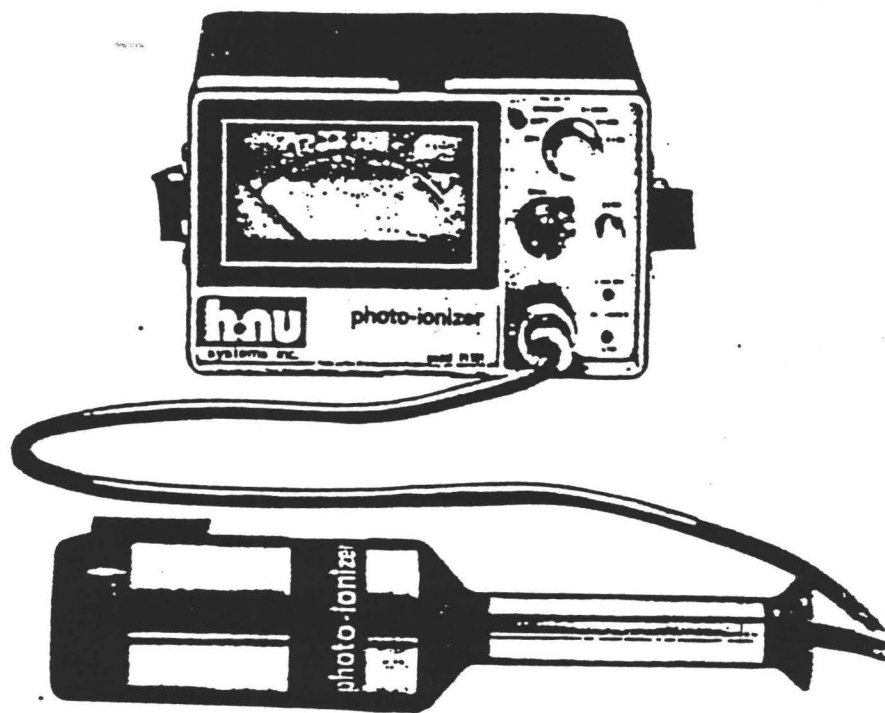
Organic Vapor Analyzer (OVA)

A flame ionization detector is used to monitor the presence of organic vapors. The principle benefits of monitoring with a flame ionization detector are:

- Universal organic compound response with approximately the same high sensitivity for all.
- Flame ionization will not respond to changes in relative humidity or changes in CO and CO₂ concentration.
- It is a mass sensing detector which exhibits minimal effects from changes in temperature, pressure, or flow.
- Provides excellent dynamic range and concentration linearity.

Sample gathering is done by using a small diaphragm air pump. Detection requires a hydrogen delivery system, a sample delivery system, and an electronic amplification and display system. The hydrogen delivery system provides an eight hour supply of hydrogen gas (with a precisely controlled flow) to the detector. The sample delivery system provides air to the detector chamber to maintain the flame combustion and introduce the organic air contaminants for analysis.

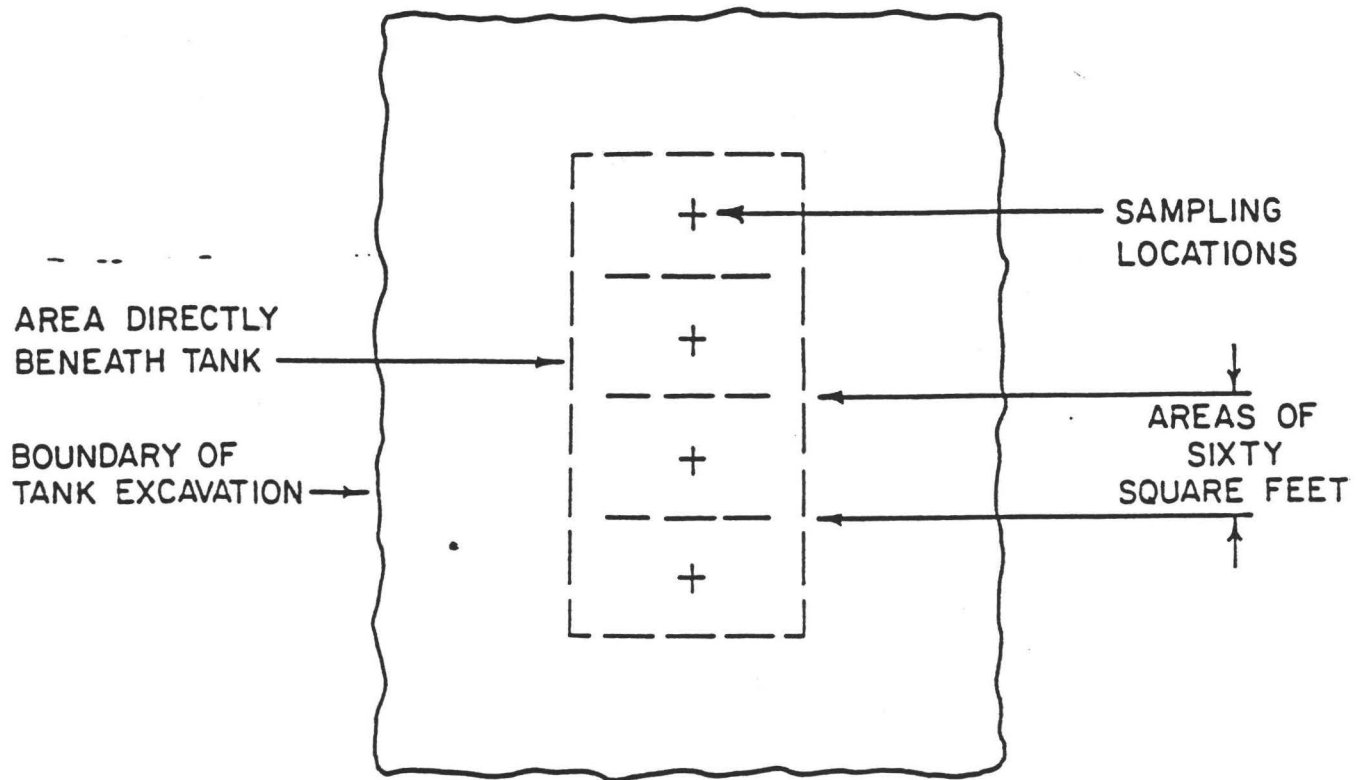
PHOTO-IONIZATION DETECTOR



The photo-ionizer is used to measure the concentration of a wide variety of species in the atmosphere. The analyzer employs the principle of photoionization for detection. The process is termed photoionization since the absorption of ultraviolet light by a molecule leads to ionization.

The sensor consists of a sealed ultraviolet light source that emits photons which are energetic enough to ionize many trace species (particularly organics) but do not ionize the major components of air such as O_2 , N_2 , CO , CO_2 , or H_2O . A chamber adjacent to the ultraviolet source contains a pair of electrodes. When a positive potential is applied to one electrode the field created drives any ions formed by the absorption of UV light to the collector electrode where the current (proportional to the concentration) is measured.

DIAGRAM A



TANK VOLUME	NUMBER OF SAMPLING AREAS
LESS THAN OR EQUAL TO 1,000 GALLONS	1
GREATER THAN 1,000 GALLONS, BUT LESS THAN OR EQUAL TO 5,000 GALLONS	2
GREATER THAN 5,000 GALLONS, BUT LESS THAN OR EQUAL TO 10,000 GALLONS	3
GREATER THAN 10,000 GALLONS	4

APPENDIX C

CHEMICAL DATA SHEETS, GROUNDWATER INTERACTION AND PUBLIC SAFETY DATA

TO: SHOLLER GLOBE CORP.

REPORT DATE: _____

3200 MAIN ST.

DATE RECEIVED: 10/16/89

KEOKUK, IA

PROJECT NO. _____

ATTN.: ANDY EDGAR

CLIENT P.O. NO. _____

RAI SAMPLE NO.

891016-01

891016-02

SAMPLE DATE

SAMPLE DESCRIPTION

B-2
16'-18'
SOIL

TANK Exc.
SEEPAGE
WATER

PARAMETER

UNITS

ug/Kg

ug/L

VOCA

DOC 671

VINYL CHLORIDE

6

1,1-DICHLOROETHANE

66

cis-1,2-DICHLOROETHENE

170

CHLOROFORM

5

1,2-DICHLOROETHANE

8

1,1,1-TRICHLOROETHANE

83

TRICHLOROETHENE

160

BENZENE

36

TETRACHLOROETHENE

32

XYLENE (TOTAL)

190

TOLUENE

210,000

170,000

METHYLENE CHLORIDE

2,600

ACETONE

2,500

2-BUTANONE

9,900

Report Approved By: _____

Barbara G. Raya-Hash

Manager Laboratory Operations

10/23/89

Table 2. -- Interim action levels in parts per billion for responses for selected organic chemicals in drinking water as of January 1986

Organic chemical	Level I	Level II	Level III	Level IV
Benzene	0-0.68	>0.68-6.8	>6.8-68	>68
Carbon tetrachloride	0-0.27	>0.27-2.7	>2.7-27	>27
Chlordane	0-0.8	>0.8-32	>32-63	>63
Dichlorobenzene(s)	0-94	>94-425	>425-750	>750
1,2-Dichloroethane	0-0.7	>0.7-7	>7-70	>70
1,1-Dichloroethylene	0-7	>7-53	>53-100	>100
Trans-1,2-dichloroethylene	0-27	>27-148	>148-270	>270
Methylene chloride	0-4.8	>4.8-47	>47-479	>479
Polychlorinated biphenyls	0-0.007	>0.007-0.07	>0.07-0.7	>0.7
Tetrachloroethylene	0-0.67	>0.67-6.6	>6.6-66	>66
1,1,1-Trichloroethane	0-20	>20-110	>110-200	>200
Trichloroethylene	0-3.1	>3.1-30	>30-309	>309
Vinyl chloride	0-0.015	>0.015-0.15	>0.15-1.5	>1.5
Xylene(s)	0-100	>100-550	>550-1200	>1200

Summary of responses

- Level I - No recommended action, random spot check sampling.
- Level II - Confirm sampling results; periodic monitoring; recommend alternative water sources and/or appropriate treatment techniques.
- Level III - Confirm sampling results; monthly monitoring; develop within one year alternative water supplies and/or appropriate treatment techniques for public community water systems; recommend appropriate remedial actions to public noncommunity water systems; and quarterly progress reports from both public community and public noncommunity water systems.
- Level IV - Confirm sampling results; immediate remedial action for both public community and public noncommunity water systems.



Randolph & Associates, Inc.

8901 NORTH INDUSTRIAL ROAD, PEORIA, ILLINOIS 61615-1589
TELEPHONE 309-692-4422

VOLATILE ORGANIC COMPOUNDS -- Target Compound List

TO: Sheller Globe Corporation
3200 Main Street
Keokuk, IA 52632
ATTN: Mr. Andy Edgar

DATE: 11-8-89
DATE REC'D: 10-16-89
PROJECT NO.: 1-0993.004.01
PAGE 3 OF 3

RAI SAMPLE NO.: --- 891016-02
SAMPLE DATE: ---
DESCRIPTION: Quant. Limit Tank Exc.
ug/l (ppb) Seepage Water

Chloromethane	10	< 10
Bromomethane	10	< 10
Vinyl Chloride	10	6 J
Chloroethane	10	< 10
Methylene Chloride	5	2,600
Acetone	10	2,500
Carbon Disulfide	5	< 5
1,1-Dichloroethene	5	< 5
1,1-Dichloroethane	5	66
1,2-Dichloroethene (total)	5	170
Chloroform	5	5
1,2-Dichloroethane	5	8
2-Butanone	10	9,900
1,1,1-Trichloroethane	5	83
Carbon Tetrachloride	5	< 5
Vinyl Acetate	10	< 10
Bromodichloromethane	5	< 5
1,2-Dichloropropane	5	< 5
cis-1,3-Dichloropropene	5	< 5
Trichloroethene	5	160
Dibromochloromethane	5	< 5
1,1,2-Trichloroethane	5	< 5
Benzene	5	36
trans-1,3-Dichloropropene	5	< 5
Bromoform	5	< 5
4-Methyl-2-Pentanone	10	< 10
2-Hexanone	10	< 10
Tetrachloroethene	5	32
1,1,2,2-Tetrachloroethane	5	< 5
Toluene	5	170,000
Chlorobenzene	5	< 5
Ethylbenzene	5	< 5
Styrene	5	< 5
Xylene (Total)	5	190

J - Estimated Concentration.

Report Approved By: *Barbara G. Rayz-Hash*

Barbara G. Rayz-Hash, Manager

JMR/L:56

An IEPA Contract Laboratory Laboratory Operations

Disclaimer: Liability to Randolph & Associates, Inc. not to exceed cost of analysis.



Randolph & Associates, Inc.

8901 NORTH INDUSTRIAL ROAD, PEORIA, ILLINOIS 61615-1589
TELEPHONE 309-692-4422

TO: Sheller Globe Corporation

3200 Main Street

Keokuk, IA 52632

ATTN: Mr. Andy Edgar

REPORT DATE: 11-8-89

DATE REC'D: 10-16-89

PROJECT NO.: 1-0993.004.01

PAGE 1 OF 3

RAI SAMPLE 891016-01
SAMPLE DATE -----

DESCRIPTION B-2 16-18'
Soil

Cyanide	< 0.010
Sulfide	116
Arsenic	11.5
Barium	63.4
Cadmium	1.85
Chromium	9.18
Lead	22.6
Mercury	< 0.020
Selenium	< 0.050
Silver	< 0.10
VOCs, ug/kg	*

*See Attached

Results in mg/kg unless otherwise specified.

Report Approved By: Barbara G. Ray-Hash
Barbara G. Ray-Hash
Manager of Laboratory Operations

Analysis in accordance with procedures itemized in 40 CFR Part 136.
JMR/L:56

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Randolph & Associates, Inc.

8901 NORTH INDUSTRIAL ROAD, PEORIA, ILLINOIS 61615-1589
TELEPHONE 309-692-4422

VOLATILE ORGANIC COMPOUNDS -- Target Compound List

TO: Sheller Globe Corporation
3200 Main Street
Keokuk, IA 52632
ATTN: Mr. Andy Edgar

DATE: 11-8-89
DATE REC'D: 10-16-89
PROJECT NO.: 1-0993.004.01
PAGE 2 OF 3

RAI SAMPLE NO.: --- 891016-01
SAMPLE DATE: ---
DESCRIPTION: Quant. Limit B-2 16-18'
ug/kg (ppb) Soil

Chloromethane	10	< 10
Bromomethane	10	< 10
Vinyl Chloride	10	< 10
Chloroethane	10	< 10
Methylene Chloride	5	< 5
Acetone	10	< 10
Carbon Disulfide	5	< 5
1,1-Dichloroethene	5	< 5
1,1-Dichloroethane	5	< 5
1,2-Dichloroethene (total)	5	< 5
Chloroform	5	< 5
1,2-Dichloroethane	5	< 5
2-Butanone	10	< 10
1,1,1-Trichloroethane	5	< 5
Carbon Tetrachloride	5	< 5
Vinyl Acetate	10	< 10
Bromodichloromethane	5	< 5
1,2-Dichloropropane	5	< 5
cis-1,3-Dichloropropene	5	< 5
Trichloroethene	5	< 5
Dibromochloromethane	5	< 5
1,1,2-Trichloroethane	5	< 5
Benzene	5	< 5
trans-1,3-Dichloropropene	5	< 5
Bromoform	5	< 5
4-Methyl-2-Pentanone	10	< 10
2-Hexanone	10	< 10
Tetrachloroethene	5	< 5
1,1,2,2-Tetrachloroethane	5	< 5
Toluene	5	210,000
Chlorobenzene	5	< 5
Ethylbenzene	5	< 5
Styrene	5	< 5
Xylene (Total)	5	< 5

Report Approved By: *Barbara G. Raya-Hash*

An IEPA Contract Laboratory

Barbara G. Raya-Hash, Manager
Laboratory Operations

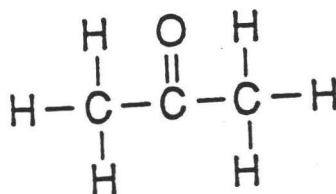
JMR/L:56

Disclaimer: Liability to Randolph & Associates, Inc. not to exceed cost of analysis.

ACETONE

Synonyms: Chevron acetone; Dimethylformaldehyde; Dimethylketal; Dimethyl ketone; DMK; Ketone propane; β -Ketopropane; Methyl ketone; Propanone; 2-Propanone; Pyroacetic acid; Pyroacetic ether; RCRA waste number U002; UN 1090.

Structural Formula:



CHEMICAL DESIGNATIONS

CAS Registry Number: 67-64-1

DOT Designation: 1090

Empirical Formula: $\text{C}_3\text{H}_6\text{O}$

Formula Weight: 58.08

RTECS Number: AL 3150000

PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Colorless, volatile liquid with a sweet fragrant odor.

Boiling Point: 56.2 °C [1].

Henry's Law Constant: $3.97 \times 10^{-5} \text{ atm}\cdot\text{m}^3/\text{mol}$ at 25 °C [2].

Ionization Potential: 9.69 eV [3].

Log K_{oc} : -0.43 using method of Rao and Davidson [4].

Log K_{ow} : -0.24 [5].

Melting Point: -95.35 °C [1].

Acetone

Solubility in Organics: Soluble in ethanol, ether, benzene, and chloroform [6].

Solubility in Water: Miscible in all proportions.

Specific Density: 0.7899 at 20/4 °C [1]; 0.7912 at 20/4 °C [7].

Transformation Products: No data found.

Vapor Density: 2.37 g/L at 25 °C, 2.01 (air = 1).

Vapor Pressure: 266 mm at 25 °C [3]; 89 mm at 5 °C, 270 mm at 30 °C, 400 mm at 39.5 °C [8]; 760 mm at 56.5 °C, 1,520 mm at 78.6 °C, 3,800 mm at 113.0 °C, 7,600 mm at 144.5 °C, 15,200 mm at 181.0 °C, 30,400 mm at 214.5 °C [1]; 180 mm at 20 °C [9].

FIRE HAZARDS

Flash Point: -17 °C [3].

Lower Explosive Limit (LEL): 2.6% [3].

Upper Explosive Limit (UEL): 12.8% [3].

HEALTH HAZARD DATA

Immediately Dangerous to Life or Health (IDLH): 20,000 ppm [3].

Permissible Exposure Limits (PEL) in Air: 1,000 ppm ($\approx 2,350 \text{ mg/m}^3$) [10]; 250 ppm ($\approx 590 \text{ mg/m}^3$) 10-hour TWA [3]; 750 ppm ($\approx 1,780 \text{ mg/m}^3$) TWA, 1,000 ppm STEL [9].

MANUFACTURING

Selected Manufacturers:

Allied Chemical Corp.
Specialty Chemical Division
Wilmington Turnpike
Marcus Hook, PA 19061

Acetone

Shell Chemical Co.
Industrial Chemical Division
Houston, TX 77001

Union Carbide Corp.
Chemicals and Plastics Division
New York, NY 10017

Uses: Intermediate for chemicals (methyl isobutyl ketone, methyl isobutyl carbinol, methyl methacrylate, bisphenol-A); paint, varnish, and lacquer solvent; spinning solvent for cellulose acetate; to clean and dry parts for precision equipment; solvent for potassium iodide, potassium permanganate, cellulose acetate, nitrocellulose; acetylene; delustrant for cellulose acetate fibers; specification testing for vulcanized rubber products; extraction of principals from animal and plant substances; ingredient in nail polish remover; sealants and adhesives; pharmaceutical manufacturing; organic synthesis.

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BENZENE

Synonyms: Annulene; Benxole; Benzol; Benzole; Benzolene; Bicarburet of hydrogen; Carbon oil; Coal naphtha; Coal tar naphtha; Cyclohexatriene; Mineral naphthalene; Motor benzol; NCI-C55276; Nitration benzene; Phene; Phenyl hydride; Pyrobenzol; Pyrobenzole; RCRA waste number U019; UN 1114.

Structural Formula:



CHEMICAL DESIGNATIONS

CAS Registry Number: 71-43-2

DOT Designation: 1114

Empirical Formula: C_6H_6

Formula Weight: 78.11

RTECS Number: CY 1400000

PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Clear, colorless to light yellow watery-liquid with an aromatic or gasoline-like odor.

Boiling Point: 80.100 °C [1].

Henry's Law Constant: 0.00548 atm·m³/mol at 25 °C [2]; 0.00538 atm·m³/mol [3].

Ionization Potential: 9.25 eV [4]; 9.56 eV [5].

Log K_{ow} : 1.69 [6]; 1.92 [7]; 1.96, 2.00 [8].

Log K_{ow} : 2.13 [9]; 2.11 [10]; 1.56, 2.15 [11]; 2.12 [12]; 1.95 [13].

Benzene

Melting Point: 5.533 °C [1].

Solubility in Organics: Freely miscible with ethanol, ether, glacial acetic acid, acetone, chloroform, and carbon tetrachloride [14].

Solubility in Water: 1,780 mg/L at 20 °C [15]; 820 mg/L at 22 °C [16]; 1,800 mg/L at 25 °C [17]; 0.093 vol% at 20 °C [18]; 1,790 mg/L at 25 °C [19]; 1,750 mg/L at 25 °C [20]; 1,850 mg/L at 30 °C [21]; 1,755 mg/L at 25 °C [22]; 1,740 mg/L at 25 °C [23]; 1,780 mg/L at 25 °C [24]; 1,791 mg/L at 25 °C [25]; 0.153 wt% at 0 °C, 0.163 wt% at 10 °C, 0.175 wt% at 20 °C, 0.180 wt% at 25 °C, 0.190 wt% at 30 °C, 0.206 wt% at 40 °C, 0.225 wt% at 50 °C, 0.250 wt% at 60 °C, 0.277 wt% at 70 °C, 0.344 wt% at 80 °C, 0.393 wt% at 90 °C, 0.504 wt% at 107.4 °C [26]; 1,678 ppm at 0 °C, 1,755 ppm at 25 °C [27]; 1,740 mg/L at 25 °C, 1,391 mg/L in artificial seawater at 25 °C [28]; 1,710 mg/L at 20 °C [29]; 1,696 ppm at 25.00 °C [30]; 1,860 ppm at 25 °C [31]; 1,800 ppm at 25 °C [32]; 1,000 mg/L in fresh water at 25 °C, 1,030 mg/L in salt water at 25 °C [33]; 0.18775 wt% at 23.5 °C [34]; 0.0233 M at 25 °C [35].

Specific Density: 0.8765 at 20/4 °C [36]; 0.87895 at 20/4 °C, 0.87366 at 25/4 °C [37]; 0.8784 at 20/4 °C, 0.8680 at 30/4 °C, 0.8572 at 40/4 °C [38]; 0.87378 at 25/4 °C [39].

Transformation Products: A mutant of *Pseudomonas putida* dihydroxylized benzene into *cis*-benzene glycol accompanied by partial dehydrogenation yielding catechol [40]. Bacterial dioxygenases can cleave catechol at the *ortho*- and *meta*- positions to yield *cis,cis*-muconic acid and α -hydroxymuconic semialdehyde, respectively [41].

Vapor Density: 3.19 g/L at 25 °C, 2.70 (air = 1).

Vapor Pressure: 60 mm at 15 °C, 76 mm at 20 °C, 118 mm at 30 °C [15]; 95.2 mm at 25 °C [42]; 760 mm at 80.1 °C, 1,520 mm at 103.8 °C, 3,800 mm at 142.5 °C, 7,600 mm at 178.8 °C, 15,200 mm at 221.5 °C [36]; 100 mm at 26.075 °C [1]; 397 mm at 60.3 °C, 556 mm at 70.3 °C, 764 mm at 80.3 °C, 1,031 mm at 90.3 °C, 1,370 mm at 100.3 °C [43].

FIRE HAZARDS

Flash Point: -11 °C [4].

Lower Explosive Limit (LEL): 1.3% [4].

Benzene

Upper Explosive Limit (UEL): 7.1% [4].

HEALTH HAZARD DATA

Immediately Dangerous to Life or Health (IDLH): 2,000 ppm (carcinogen) [44].

Permissible Exposure Limits (PEL) in Air: 10 ppm (≈ 30 mg/m³), 10-minute 50 ppm ceiling [45]; 0.1 ppm TWA, 1 ppm 15-minute ceiling [4]; 10 ppm TWA [46].

MANUFACTURING

Selected Manufacturers:

Commonwealth Oil Refining Co., Inc.
Penuclas, PR 00724

Phillips Petroleum Co.
Phillips Puerto Rico Core, Inc.
Banco Popular Center
Hato Rey, PR 00936

Shell Chemical Co.
Petrochemical Division
P.O. Box 2463
Houston, TX 77001

Uses: Manufacture of ethylbenzene (preparation of styrene monomer), dodecylbenzene (for detergents), cyclohexane (for nylon), nitrobenzene, aniline, maleic anhydride, diphenyl, benzene hexachloride, benzene sulfonic acid, phenol, dichlorobenzene, insecticides, pesticides, fumigants, explosives, aviation fuel, flavors, perfume, medicine, dyes, and other organic chemicals; paints, coatings, plastics and resins; food processing; photographic chemicals; nylon intermediates; paint removers; rubber cement; antiknock gasoline; solvent.

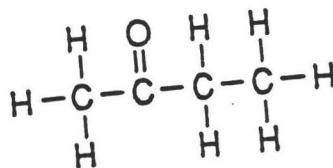
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2-BUTANONE

Synonyms: Butanone; Ethyl methyl ketone; Meectco; MEK; Methyl acetone; Methyl ethyl ketone; RCRA waste number U159; UN 1193; UN 1232.

Structural Formula:



CHEMICAL DESIGNATIONS

CAS Registry Number: 78-93-3

DOT Designation: 1193

Empirical Formula: $\text{C}_4\text{H}_8\text{O}$

Formula Weight: 72.11

RTECS Number: EL 6475000

PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Colorless liquid with a sweet mint-like odor.

Boiling Point: 79.6 °C [1].

Henry's Law Constant: $4.66 \times 10^{-5} \text{ atm}\cdot\text{m}^3/\text{mol}$ at 25 °C [2].

Ionization Potential: 9.48 eV [3].

Log K_{oc} : 0.09 using method of Rao and Davidson [4].

Log K_{ow} : 0.26 and 0.29 [5].

Melting Point: -86.9 °C [6]; -85.9 °C [7].

Solubility in Organics: Miscible with acetone, ethanol, benzene, ether [8].

2-Butanone

Solubility in Water: 353 g/L at 10 °C, 190 g/L at 90 °C [9]; 27 wt% at 20 °C [3]; 28 vol% at 20 °C [10]; 24.00 wt% at 20 °C [11]; 26.7 wt% at 20 °C [12]; 27.33 wt% at 20 °C, 25.57 wt% at 25 °C, 24.07 wt% at 30 °C [13].

Specific Density: 0.8054 at 20/4 °C [1]; 0.804 at 20/4 °C [14]; 0.8061 at 20/4 °C, 0.8047 at 20/20 °C [15].

Transformation Products: No data found.

Vapor Density: 2.94 g/L at 25 °C, 2.49 (air = 1).

Vapor Pressure: 77.5 mm at 20 °C [9]; 1 mm at -48.3 °C, 10 mm at -17.7 °C, 40 mm at 6.0 °C, 100 mm at 25.0 °C, 400 mm at 60.0 °C, 760 mm at 79.6 °C [1]; 70 mm at 20 °C [3]; 71.2 mm at 20 °C [16].

FIRE HAZARDS

Flash Point: -9 °C [17].

Lower Explosive Limit (LEL): 2% [3].

Upper Explosive Limit (UEL): 10% [3].

HEALTH HAZARD DATA

Immediately Dangerous to Life or Health (IDLH): 3,000 ppm [3].

Permissible Exposure Limits (PEL) in Air: 200 ppm ($\approx 590 \text{ mg/m}^3$) [18]; 200 ppm 10-hour TWA, 300 ppm ($\approx 885 \text{ mg/m}^3$) 15-minute ceiling [3]; 200 ppm TLV, 300 ppm STEL [19].

MANUFACTURING

Selected Manufacturers:

Celanese Chemical Co.
245 Park Ave.
New York, NY 10017

2-Butanone

Exxon Chemical Co.
P.O. Box 3272
Houston, TX 77001

Shell Chemical Co.
Industrial Chemicals Division
Houston, TX 77001

Uses: Solvent in nitrocellulose coatings, vinyl films, and "Glyptal" resins; paint removers; cements and adhesives; organic synthesis; manufacturing of smokeless powders, ketones and amines; cleaning fluids; printing; catalyst carrier; acrylic coatings.

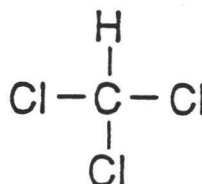
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CHLOROFORM

Synonyms: Formyl trichloride; Freon 20; Methane trichloride; Methenyl chloride; Methenyl trichloride; Methyl trichloride; NCI-C02686; R 20; R 20 (refrigerant); RCRA waste number U044; TCM; Trichloroform; Trichloromethane; UN 1888.

Structural Formula:



CHEMICAL DESIGNATIONS

CAS Registry Number: 67-66-3

DOT Designation: 1888

Empirical Formula: CHCl_3

Formula Weight: 119.38

RTECS Number: FS 9100000

PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Clear, water-white, volatile liquid with a strong, sweet, ethereal odor.

Boiling Point: 61.7 °C [1].

Henry's Law Constant: 0.0029 atm·m³/mol [2]; 0.00339 atm·m³/mol [3]; 0.00323 atm·m³/mol [4]; 0.0053 atm·m³/mol at 20 °C [5]; 0.0032 at 25 °C [6]; 0.00727 atm·m³/mol at 37 °C [7].

Ionization Potential: 11.42 eV [8].

Log K_{oc}: 1.64 [9].

Chloroform

Refractive Index: 1.97 [10]; 1.90 [11]; 1.95 [12].

Melting Point: -63.5 °C [1].

Solubility in Organics: Soluble in acetone; miscible with ethanol, ether, benzene, and ligroin [13].

Solubility in Water: 8,000 mg/L at 20 °C, 9,300 mg/L at 25 °C [14]; 8,500 mg/L at 20 °C [15]; 7,950 mg/L at 25 °C [16]; 8.22 ml/L at 20 °C [17]; 8,220 mg/L at 20 °C [18]; 9,600 mg/L at 25 °C [19]; 7,222 mg/L at 25 °C [20]; 7,840 mg/L at 25 °C [6]; 8,520 mg/L at 15 °C, 7,710 mg/L at 30 °C [21]; 0.84 wt% at 15 °C, 0.8 wt% at 20 °C, 0.76 wt% at 30 °C [22]; 0.815 wt% at 20 °C [23]; 10,620 mg/L at 0 °C, 8,950 mg/L at 10 °C, 8,220 mg/L at 20 °C, 7,760 mg/L at 30 °C [24]; 7,100 ppm at 25 °C [25]; 1% at 15 °C [26].

Specific Density: 1.4832 at 20/4 °C [1]; 1.49845 15/4 °C [27]; 1.52637 at 0/4 °C, 1.4890 at 20/4 °C, 1.48069 at 25/4 °C, 1.4081 at 60.9/4 °C [24].

Transformation Products: An anaerobic species of *Clostridium* biodegraded chloroform (a metabolite of carbon tetrachloride) by reductive dechlorination yielding methylene chloride and unidentified products [28].

Vapor Density: 4.88 g/L at 25 °C, 4.12 (air = 1).

Vapor Pressure: 160 mm at 20 °C, 245 mm at 30 °C [14]; 760 mm at 61.3 °C, 1,520 mm at 83.9 °C, 3,800 mm at 120.0 °C, 7,600 mm at 152.3 °C, 15,200 mm at 191.8 °C, 30,400 mm at 237.5 °C [1]; 150.5 mm at 20 °C [29]; 198 mm at 25 °C [3]; 100 mm at 10.4 °C [27]; 0.81 mm at -60 °C, 2.06 mm at -50 °C, 4.20 mm at -40 °C, 10.00 mm at -30 °C, 19.60 mm at -20 °C, 34.75 mm at -10 °C, 61.0 mm at 0 °C, 100.5 mm at 10 °C, 159.6 mm at 20 °C, 246.0 mm at 30 °C, 366.4 mm at 40 °C, 526.0 mm at 50 °C [24].

FIRE HAZARDS

Flash Point: Non-combustible [8].

Lower Explosive Limit (LEL): Not applicable [8].

Upper Explosive Limit (UEL): Not applicable [8].

1,1-Dichloroethane

PPG Industries, Inc.
Chemicals Group
Industrial Chemical Division
Lake Charles, LA 70601

Vulcan Materials Co.
Vulcan Chemicals Division
Geismar, LA 70734

Uses: Extraction solvent; insecticide and fumigant; preparation of vinyl chloride; paint, varnish, and finish removers; degreasing and drying metal parts; ore flotation; solvent for plastics, oils, and fats; chemical intermediate for 1,1,1-trichloroethane; in rubber cementing, fabric spreading, and fire extinguishers; formerly used as an anesthetic; organic synthesis.

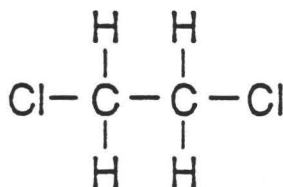
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1,2-DICHLOROETHANE

Synonyms: 1,2-Dichloroethane; Borer sol; Brocide; 1,2-DCA; 1,2-DCE; Dettaxol borer-sol; Dichloremlusion; 1,2-Dichlorethane; Dichloroethane; α,β -Dichloroethane; *sym*-Dichloroethane; Dichloroethylene; Dutch liquid; Dutch oil; EDC; ENT 1,656; Ethane dichloride; Ethene dichloride; Ethylene chloride; Ethylene dichloride; 1,2-Ethylene dichloride; Freon 150; Glycol dichloride; NCI-C00511; RCRA waste number U077; UN 1184.

Structural Formula:



CHEMICAL DESIGNATIONS

CAS Registry Number: 107-06-2

DOT Designation: 2362

Empirical Formula: $\text{C}_2\text{H}_4\text{Cl}_2$

Formula Weight: 98.96

RTECS Number: KI 0525000

PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Colorless liquid with a pleasant odor.

Boiling Point: 83.5 °C [1].

Henry's Law Constant: 9.1×10^{-4} atm·m³/mol [2]; 0.0011 atm·m³/mol [3]; 9.8×10^{-4} atm·m³/mol at 25 °C [4]; 0.00131 atm·m³/mol at 25 °C [5]; 0.00225 atm·m³/mol at 37 °C [6].

Ionization Potential: 9.64 eV [7]; 11.04 eV [8].

Log K_{ow} : 1.15 [2]; 1.279 [9].

1,2-Dichloroethane

Log K_{ow} : 1.48 [10]; 1.45 [11].

Melting Point: -35.3 °C [1].

Solubility in Organics: Miscible with ethanol, chloroform, and ether [12].

Solubility in Water: 9,200 mg/L at 0 °C, 8,690 mg/L at 20 °C [13]; in 120 parts water [14]; 8,300 mg/L at 25 °C [3]; 7,986 mg/L at 25 °C [11]; 8,720 mg/L at 15 °C, 9,000 mg/L at 30 °C [15]; 8,800 mg/L at 20 °C [16]; 0.81 wt% at 20 °C [17]; 8,450 ppm at 20 °C [9]; 0.873 mass% at 0 °C [10]; 8,650 mg/L at 25 °C [18]; 0.87% [19].

Specific Density: 1.2351 at 20/4 °C [1]; 1.253 at 20/4 °C [20]; 1.28164 at 0/4 °C, 1.26000 at 15/4 °C, 1.25280 at 20/4 °C, 1.24530 at 25/4 °C, 1.23831 at 30/4 °C [21].

Transformation Products: No data found.

Vapor Density: 4.04 g/L at 25 °C, 3.42 (air = 1).

Vapor Pressure: 25 mm at 0 °C, 40 mm at 10 °C, 64 mm at 20 °C, 100 mm at 30 °C, 160 mm at 40 °C, 240 mm at 50 °C, 350 mm at 60 °C, 500 mm at 70 °C, 700 mm at 80 °C, 760 mm at 83.5 °C [21]; 87 mm at 25 °C [14].

FIRE HAZARDS

Flash Point: 13 °C (open cup) [7]; 17 °C, 21 °C (open cup) [21].

Lower Explosive Limit (LEL): 6.2% [7].

Upper Explosive Limit (UEL): 16% [7].

HEALTH HAZARD DATA

Immediately Dangerous to Life or Health (IDLH): Potential human carcinogen [7].

Permissible Exposure Limits (PEL) in Air: 50 ppm, 100 ppm ceiling, 300 ppm 5-minute/3-hour peak [22]; 1 ppm 10-hour TWA, 2 ppm 15-minute ceiling [7]; 10 ppm ($\approx 40 \text{ mg/m}^3$) TWA [14].

1,2-Dichloroethane

MANUFACTURING

Selected Manufacturers:

Aldrich Chemical Co.
940 West Saint Paul Ave.
Milwaukee, WI 53233

Fluka Chemical Corp.
980 South Second St.
Ronkonkoma, NY 11779

Pfaltz & Bauer, Inc.
172 East Aurora St.
Waterbury, CT 06708

Uses: Vinyl chloride solvent; lead scavenger in antiknock unleaded gasoline; paint, varnish, and finish remover; metal degreasers; soaps and scouring compounds; wetting and penetrating agents; organic synthesis; ore flotation; tobacco flavoring; soil and foodstuff fumigant.

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trans-1,2-Dichloroethylene

Melting Point: -50 °C [1].

Solubility in Organics: Miscible with acetone, ethanol, ether, and very soluble in benzene and chloroform [10].

Solubility in Water: 600 mg/L at 20 °C [11]; 6,300 mg/L at 25 °C [12]; 0.63 wt% at 25 °C [13]; 6,260 mg/L at 25 °C [14].

Specific Density: 1.2565 at 20/4 °C [1]; 1.27 at 25/4 °C (mixture of *cis*- and *trans*- isomers) [15]; 1.2631 at 10/4 °C [16].

Transformation Product: In a methanogenic aquifer material, *trans*-1,2-dichloroethylene biodegraded to vinyl chloride [17]. Under anoxic conditions *trans*-1,2-dichloroethylene, when subjected to indigenous microbes in uncontaminated sediments, degraded to vinyl chloride [18].

Vapor Density: 3.96 g/L at 25 °C, 3.35 (air = 1).

Vapor Pressure: 200 mm at 14 °C [11]; 760 mm at 47.8 °C, 1,520 mm at 69.8 °C, 3,800 at 104.0 °C, 7,600 mm at 135.7 °C, 15,200 mm at 174.0 °C, 30,400 mm at 220.0 °C [1]; 40 mm at -20 °C, 64 mm at -10 °C, 113 mm at 0 °C, 185 mm at 10 °C, 265 mm at 20 °C, 410 mm at 30 °C, 575 mm at 40 °C, 760 mm at 47.7 °C [16].

FIRE HAZARDS

Flash Point: 2 °C [19].

Lower Explosive Limit (LEL): 9.7% [19].

Upper Explosive Limit (UEL): 12.8% [19].

HEALTH HAZARD DATA

Immediately Dangerous to Life or Health (IDLH): No data found, however, a level of 4,000 ppm has been established for 1,2-dichloroethylene containing both the *cis*- and *trans*- isomers [20].

Permissible Exposure Limits (PEL) in Air: No standards set, however, for the compound containing both isomers the TLV is 200 ppm (≈ 790 mg/m³) [21].

trans-1,2-Dichloroethylene

MANUFACTURING

Selected Manufacturers:

Fluka Chemical Corp.
980 South Second St.
Ronkonkoma, NY 11779

Pfaltz and Bauer, Inc.
126-04 Northern Blvd.
Flushing, NY 11368

Uses: A mixture of *cis*- and *trans*- isomers is used as a solvent for fats, phenols, camphor, etc.; ingredient in perfumes; low temperature solvent for sensitive substances such as caffeine; refrigerant; organic synthesis.

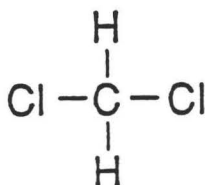
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METHYLENE CHLORIDE

Synonyms: Aerothene MM; DCM; Dichloromethane; Freon 30; Methane dichloride; Methylene bichloride; Methylene dichloride; Narcotil; NCI-C50102; RCRA waste number U080; Solaesthin; Solmethine; UN 1593.

Structural Formula:



CHEMICAL DESIGNATIONS

CAS Registry Number: 75-09-2

DOT Designation: 1593

Empirical Formula: CH_2Cl_2

Formula Weight: 84.93

RTECS Number: PA 8050000

PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Colorless liquid with a sweet, penetrating ethereal odor.

Boiling Point: 40.2 °C [1].

Henry's Law Constant: 0.0020 atm·m³/mol [2]; 0.00319 atm·m³/mol [3]; 0.00269 atm·m³/mol at 25 °C [4]; 0.00218 atm·m³/mol at 25 °C [5]; 0.00353 atm·m³/mol at 37 °C [6].

Ionization Potential: 11.35 eV [7].

Log K_{∞} : 0.94 [8].

378 Methylene chloride

Log K_{ow} : 1.30 [9]; 1.25 [10].

Melting Point: -95.1 °C [11]; -96.7 °C [12].

Solubility in Organics: Miscible with ethanol and ether [13].

Solubility in Water: 20,000 mg/L at 20 °C, 16,700 mg/L at 25 °C [14]; 1.3 wt% at 20 °C [7]; 13,000 mg/L at 25 °C [15]; 19,400 ppm at 25 °C [4]; 13,200 mg/L at 25 °C [16]; 23,600 mg/L at 0 °C, 21,200 mg/L at 10 °C, 19,700 at 30 °C [12]; 19,000 ppm at 25 °C [17].

Specific Density: 1.3266 at 20/4 °C [11]; 1.378 at 0/4 °C [12].

Transformation Products: Under laboratory conditions, methylene chloride hydrolyzed with subsequent oxidation and reduction to produce methyl chloride, methanol, formic acid, and formaldehyde [18].

Vapor Density: 3.47 g/L at 25 °C, 2.93 (air = 1).

Vapor Pressure: 147.4 mm 0 °C, 229.7 mm at 10 °C, 348.9 mm at 20 °C, 511.4 mm at 30 °C, 600 mm at 35 °C [12]; 1 mm at -70.0 °C, 10 mm at -43.3 °C, 40 mm at -22.3 °C, 100 mm at -6.3 °C, 400 mm at 24.1 °C, 760 mm at 40.7 °C [11]; 440 mm at 25 °C [19]; 362.4 mm at 20 °C [20]; 455 mm at 25 °C [21]; 380 mm at 22 °C [22].

FIRE HAZARDS

Flash Point: None [23]; ≥ 30 °C [24].

Lower Explosive Limit (LEL): 12% [7].

Upper Explosive Limit (UEL): 19% [7].

HEALTH HAZARD DATA

Immediately Dangerous to Life or Health (IDLH): 5,000 ppm (carcinogen) [25].

Permissible Exposure Limits (PEL) in Air: 500 ppm, 1,000 ppm ceiling 5 minute/2-hour peak [26]; lowest feasible limit 175 ppm (≈ 175 mg/m³) [19].

Methylene chloride

MANUFACTURING

Selected Manufacturers:

Aldrich Chemical Co.
940 West Saint Paul Ave.
Milwaukee, WI 53233

Fluka Chemical Corp.
980 South Second St.
Ronkonkoma, NY 11779

Pfaltz & Bauer, Inc.
172 East Aurora St.
Waterbury, CT 06708

Uses: Low temperature solvent; ingredient in paint and varnish removers; cleaning, degreasing and drying metal parts; fumigant; manufacturing of aerosols; refrigerant; dewaxing; blowing agent in foams; solvent for cellulose acetate; organic synthesis

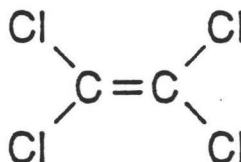
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TETRACHLOROETHYLENE

Synonyms: Ankilostin; Antisol 1; Carbon bichloride; Carbon dichloride; Dee-Solv; Didakene; Dow-per; ENT 1,860; Ethylene tetrachloride; Fedal-UN; NCI-C04580; Nema; PCE; PER; Perawin; PERC; Perchlor; Perchlorethylene; Perchloroethylene; Perclene; Perclene D; Percosolv; Perk; Perklone; Persec; RCRA waste number U210; Tetlen; Tetracap; Tetrachlorethylene; Tetrachloroethene; 1,1,2,2-Tetrachloroethylene; Tetraleno; Tetralox; Tetravec; Tetroguer; Tetropil; UN 1897.

Structural Formula:



CHEMICAL DESIGNATIONS

CAS Registry Number: 127-18-4

DOT Designation: 1897

Empirical Formula: C_2Cl_4

Formula Weight: 165.83

RTECS Number: KX 3850000

PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Colorless liquid with a chloroform or sweet ethereal odor.

Boiling Point: 121.2 °C [1].

Henry's Law Constant: 0.0153 atm·m³/mol [2]; 0.0131 atm·m³/mol [3]; 0.00287 atm·m³/mol [4]; 0.0592 atm·m³/mol at 37 °C [5].

Ionization Potential: 9.32 eV [6]; 9.71 eV [7].

Log K_{ow}: 2.42 [8]; 2.56 [3]; 2.322 [9].

Tetrachloroethylene

Log K_{ow} : 2.60 [10]; 2.88 [11]; 2.10 [12]; 2.53 [13].

Melting Point: -19 °C [14]; -22.4 °C [15].

Solubility in Organics: Soluble in ethanol, benzene, ether [16], and oils [17].

Solubility in Water: 150 mg/L at 25 °C [10]; 150 mg/L at 20 °C [18]; 2200 mg/L at 20 °C [19]; 400 mg/L at 25 °C [20]; 485 ppm at 25 °C [12]; 149 mg/L at 20 °C [21].

Specific Density: 1.6227 at 20/4 °C [14]; 1.63120 at 10/4 °C, 1.63109 at 15/4 °C, 1.62260 at 20/4 °C, 1.60640 at 30/4 °C, 1.44865 at 120/4 °C [22].

Transformation Products: Sequential dehalogenation by microbes under laboratory conditions produced trichloroethylene, *cis*-1,2-dichloroethylene, *trans*-1,2-dichloroethylene, and vinyl chloride [23].

Vapor Density: 6.78 g/L at 25 °C, 5.72 (air = 1).

Vapor Pressure: 1 mm at -20.6 °C, 5 mm at 2.4 °C, 10 mm at 13.8 °C, 20 mm at 26.3 °C, 41 mm at 40 °C, 67 mm at 50 °C, 104 mm at 60 °C, 155.3 mm at 70 °C, 226.0 mm at 80 °C, 319.2 mm at 90 °C, 438.5 mm at 100 °C, 591.6 mm at 110 °C, 760 mm at 121.2 °C [22]; 24 mm at 30 °C [10]; 100 mm at 61.3 °C, 400 mm at 100.0 °C, 760 mm at 120.8 °C [14]; 19 mm at 25 °C [24]; 20 mm at 25 °C [25]; 15.8 mm at 22 °C [26]; 14 mm at 20 °C [27].

FIRE HAZARDS

Flash Point: Not flammable [6].

Lower Explosive Limit (LEL): Not flammable [15].

Upper Explosive Limit (UEL): Not flammable [15].

HEALTH HAZARD DATA

Immediately Dangerous to Life or Health (IDLH): 500 ppm (carcinogen) [15].

Tetrachloroethylene

Permissible Exposure Limits (PEL) in Air: 100 ppm, 200 ppm ceiling, 300 ppm 5-minute/3-hour peak [28]; lowest feasible limit [6]; 50 ppm ($\approx 340 \text{ mg/m}^3$), 200 ppm ($\approx 1,340 \text{ mg/m}^3$) STEL [24].

MANUFACTURING

Selected Manufacturers:

Dow Chemical Co.
Midland, MI 48640

PPG Industries, Inc.
Industrial Chemicals Division
Barberton, OH 44203

Vulcan Materials Co.
Chemicals Division
Wichita, KS 67201

Uses: Dry cleaning fluid; degreasing and drying metals and other solids; solvent for waxes, greases, fats, oils, gums; manufacturing printing inks and paint removers; preparation of fluorocarbons and trichloroacetic acid; vermifuge; organic synthesis.

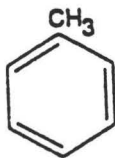
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5. Sato, A. and T. Nakajima. "A Structure-Activity Relationship of Some Chlorinated Hydrocarbons," *Arch. Environ. Health*, 34(2):69-75 (1979).

TOLUENE

Synonyms: Antisal 1a; Methacide; Methylbenzene; Methylbenzol; NCI-1272; Phenylmethane; RCRA waste number U220; Toluol; Tolu-sol; UN 1294.

Structural Formula:



CHEMICAL DESIGNATIONS

CAS Registry Number: 108-88-3

DOT Designation: 1294

Empirical Formula: C_7H_8

Formula Weight: 92.14

RTECS Number: XS 5250000

PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Colorless, water-white liquid with a pleasant odor similar to benzene.

Boiling Point: 110.6 °C [1].

Henry's Law Constant: 0.0067 atm·m³/mol [2]; 0.00674 atm·m³/mol at 25 °C [3].

Ionization Potential: 8.82 eV [4].

Log K_{ow} : 2.06 [5]; 2.18 [6].

Log K_{ow} : 2.65 [7]; 2.69 [8]; 2.21 [9]; 2.63 [10]; 2.50 [11]; 2.11, 2.73, 2.80 [12]; 2.79 [13].

Toluene

Melting Point: -95 °C [1].

Solubility in Organics: Soluble in acetone, carbon disulfide, and ligroin; miscible with acetic acid, ethanol, benzene, ether, chloroform, and other solvents [14].

Solubility in Water: 515 mg/L at 20 °C [15]; 524 mg/L at 25 °C [16]; 0.05 wt% at 20 °C [4]; 490 mg/L at 25 °C, 0.07 vol% at 20 °C [17]; 535 mg/L at 25 °C [18]; 506.7 mg/L at 25 °C, 418.5 mg/L in natural seawater at 25 °C [19]; 515 at 25 °C [20]; 627 mg/L at 25 °C [21]; 530 mg/L at 25 °C [22]; 570 mg/L at 30 °C [23]; 724 mg/L at 0 °C [24]; 0.0368 wt% at 10 °C, 0.0492 wt% at 25 °C, 0.0344 vol% at 25 °C, 0.627 g/L at 25 °C, 0.057 wt% at 30 °C [25]; 724 ppm at 0 °C, 573 ppm at 25 °C [26]; 534.8 ppm at 25 °C, 379.3 ppm in artificial seawater at 25 °C [27]; 554.0 mg/L at 25 °C, 402.0 mg/L in artificial seawater at 25 °C [28]; 0.00628 M at 25 °C [7]; 580 ppm at 25.00 °C [29]; 220 mg/L in fresh water at 25 °C, 230 mg/L in salt water at 25 °C [30]; 0.0665 wt% at 23.5 °C [31]; 470 mg/L at 30 °C [32]; 0.00669 M at 25 °C [33].

Specific Density: 0.8669 at 20/4 °C [1]; 0.86697 at 20/4 °C, 0.86233 at 25/4 °C [34]; 0.8666 at 20/4 °C, 0.8573 at 30/4 °C, 0.8480 at 40/4 °C [35].

Transformation Products: A mutant of *Pseudomonas putida* oxidized toluene to (+)-*cis*-2,3-dihydroxy-1-methylcyclohexa-1,4-diene [36]. Other metabolites identified in the microbial degradation of toluene include *cis*-2,3-dihydroxy-2,3-dihydrotoluene, 3-methyl catechol, benzyl alcohol, benzaldehyde, benzoic acid, and catechol [15]. In an methanogenic aquifer material, toluene degraded completely to carbon dioxide [37].

Vapor Density: 3.77 g/L at 25 °C, 3.18 (air = 1).

Vapor Pressure: 22 mm at 20 °C, [15]; 1 mm at -26.7 °C, 10 mm at 6.4 °C, 40 mm at 31.8 °C, 100 mm at 51.9 °C, 400 mm at 89.5 °C, 760 mm at 110.6 °C [1]; 36.7 mm at 30 °C [38].

FIRE HAZARDS

Flash Point: 4.4 °C [4].

Lower Explosive Limit (LEL): 1.3% [4].

Toluene

Explosive Limit (UEL): 7.1% [4].

HEALTH HAZARD DATA

Immediately Dangerous to Life or Health (IDLH): 2,000 ppm [4].

Permissible Exposure Limits (PEL) in Air: 200 ppm, 300 ppm ceiling, 300 ppm 10-minute peak [39]; 100 ppm 10-hour time weighted average, 300 ppm 10-minute ceiling [4]; 100 ppm (≈ 375 mg/m³), 150 ppm (≈ 560 mg/m³) STEL [40].

MANUFACTURING

Selected Manufacturers:

Exxon Chemical Co.
Houston, TX 77001

Shell Chemical Co.
Petrochemicals Division
Houston, TX 77001

Sun Oil Co.
St. Davids, PA 19087

Uses: Manufacturing of caprolactum, saccharin, medicines, dyes, perfumes, benzoic acid, trinitrotoluene (TNT), and other benzene derivatives; solvent for paints and coatings, gums, resins, rubber, oils, and vinyl compounds; adhesive solvent in plastic toys and model airplanes; diluent and thinner for nitrocellulose lacquers; detergent manufacturing; aviation gasoline and high-octane blending stock; preparation of toluenediisocyanate for polyurethane resins.

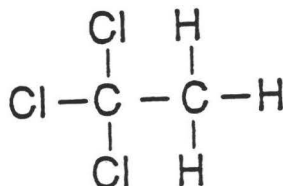
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1,1,1-TRICHLOROETHANE

Synonyms: Acrothene; Acrothene TT; Baltana; Chloroethene; Chloroethene NU; Chlorothane NU; Chlorothene; Chlorothene NU; Chlorothene VG; Chlorten; Genklene; Inhibisol; Methyl chloroform; Methyltrichloromethane; NCI-C04626; RCRA waste number U226; Solvent III; α -T; 1,1,1-TCA; 1,1,1-TCE; α -Trichloroethane; Tri-ethane; UN 2831.

Structural Formula:



CHEMICAL DESIGNATIONS

CAS Registry Number: 71-55-6

DOT Designation: 2831

Empirical Formula: $\text{C}_2\text{H}_3\text{Cl}_3$

Formula Weight: 133.40

RTECS Number: KJ 2975000

PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Colorless, watery liquid with an odor similar to chloroform. Readily corrodes aluminum and aluminum alloys.

Boiling Point: 74.1 °C [1].

Henry's Law Constant: 0.018 atm-m³/mol [2]; 0.013 atm-m³/mol [3]; 0.0162 atm-m³/mol at 25 °C [4]; 0.015 atm-m³/mol at 20 °C [5]; 0.0274 atm-m³/mol at 37 °C [6].

Ionization Potential: No data found.

Log K_{ow}: 2.18 [3]; 2.017 [7].

1,1,1-Trichloroethane

Log K_{ow} : 2.18 [8]; 2.48 [9]; 2.49 [10]; 2.47 [11]; 2.17 [12]

Melting Point: -30.4 °C [1]; < -39 °C [13]; -32.62 °C [14]

Solubility in Organics: Sparingly soluble in ethanol; freely soluble in carbon disulfide and benzene. Also soluble in ether, methanol and carbon tetrachloride [15].

Solubility in Water: 4,400 mg/L at 20 °C [16]; 480 mg/L at 20 °C [17]; 300 mg/L at 25 °C [18]; 950 mg/L at 25 °C [2]; 0.07 wt% at 20 °C [19]; 720 mg/L at 25 °C [3]; 1,334 mg/L at 25 °C [9]; 730 mg/L at 20 °C [20]; 1,550 mg/L at 20 °C [10]; 0.132 wt% at 20 °C [21]; 1,360 ppm at 20 °C [7]; 0.44 mass% at 20 °C [22]; 0.1175 wt% 23.5 °C [23].

Specific Density: 1.3390 at 20/4 °C [1]; 1.31 at 20/4 °C [13]; 1.336 at 20/4 °C [24]; 1.37068 at 0/4 °C, 1.34587 at 15/4 °C, 1.3296 at 30/4 °C [14].

Transformation Products: Microbial degradation by sequential dehalogenation under laboratory conditions produced 1,1-dichloroethane, *cis*-1,2-dichloroethylene, *trans*-1,2-dichloroethylene, chloroethane, and vinyl chloride; Hydrolysis products included acetic acid and 1,1-dichloroethylene [25]. An anaerobic species of *Clostridium* biotransformed 1,1,1-trichloroethane yielding 1,1-dichloroethane, acetic acid, and unidentified products [26].

Vapor Density: 5.45 g/L at 25 °C, 4.60 (air = 1).

Vapor Pressure: 37 mm at 0 °C, 62 mm at 10 °C, 100 mm at 20 °C, 158 mm at 30 °C, 240 mm at 40 °C, 340 mm at 50 °C, 470 mm at 60 °C, 660 mm at 70 °C, 900 mm at 80 °C [14]; 1 mm at -52.0 °C, 10 mm at -21.9 °C, 40 mm at 1.6 °C, 100 mm at 20.0 °C, 400 mm at 54.6 °C, 768 mm at 74.1 °C [1]; 124 mm at 25 °C [9]; 96 mm at 20 °C [27].

FIRE HAZARDS

Flash Point: None [28]; ≤ 25 °C [29].

Lower Explosive Limit (LEL): 7.5% [28].

Upper Explosive Limit (UEL): 12.5% [28].

1,1,1-Trichloroethane

HEALTH HAZARD DATA

Immediately Dangerous to Life or Health (IDLH): 1,000 ppm [13].
Permissible Exposure Limits (PEL) in Air: 350 ppm ($\approx 1,900 \text{ mg/m}^3$) [30];
350 ppm 15-minute ceiling [19]; 350 ppm ($\approx 1,900 \text{ mg/m}^3$), 450 ppm
($\approx 2,450 \text{ mg/m}^3$) STEL [31].

MANUFACTURING

Selected Manufacturers:

Dow Chemical Co.
Midland, MI 48640

PPG Industries, Inc.
Industrial Chemicals Division
1 Gateway Center
Pittsburgh, PA 15222

Vulcan Materials Co.
Chemicals Division
Wichita, KS 67201

Uses: Organic synthesis; solvent for metal cleaning of precision instruments; textile processing; aerosol propellants; pesticide.

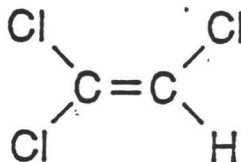
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TRICHLOROETHYLENE

Synonyms: Acetylene trichloride; Algilen; Anamenth; Benzinol; Blacosolv; Blancosolv; Cecolene; Chlorilen; 1-Chloro-2,2-dichloroethylene; Chlorylea; Chlorylen; Circosolv; Crawhaspol; Densinfluat; 1,1-Dichloro-2-chloroethylene; Dow-tri; Dukeron; Ethinyl trichloride; Ethylene trichloride; Fleck-flip; Flock-flip; Fluate; Gemalgene; Germalgene; Lanadin; Lethurin; Narcogen; Narkogen; Narkosoid; NCI-C04546; Nialk; Perm-a-chlor; Perm-a-clor; Petzinol; Philex; RCRA waste number U228; TCE; Threthylen; Threthylene; Trethylene; Tri; Triad; Trial; Triasol; Trichloran; Trichloren; Trichloroethene; 1,1,2-Trichloroethene; 1,2,2-Trichloroethene; 1,1,2-Trichloroethylene; 1,2,2-Trichloroethylene; Tri-clene; Trielene; Trieline; Triklone; Trilen; Trilene; Triline; Trimar; Triol; Tri-plus; Tri-plus M; UN 1710; Vestrol; Vitran; Westrosol.

Structural Formula:



CHEMICAL DESIGNATIONS

CAS Registry Number: 79-01-6

DOT Designation: 1710

Empirical Formula: C_2HCl_3

Formula Weight: 131.39

RTECS Number: KX 4550000

PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Clear, colorless, watery-liquid with a chloroform-like odor.

Boiling Point: 87.2 °C [1]; 86.7 °C [2].

Trichloroethylene

Henry's Law Constant: 0.0091 atm-m³/mol [3]; 0.0117 atm-m³/mol [4]; 0.0099 atm-m³/mol at 20 °C [5]; 0.0196 atm-m³/mol at 37 °C [6].

Ionization Potential: 9.47 eV [7]; 9.94 eV [8].

Log K_{ow}: 1.81 [9]; 2.10 [10]; 2.025 [11].

Log K_{ow}: 2.53 [12]; 2.29 [13]; 2.42 [14]; 2.60 [15]; 3.24, 3.30 [16]; 2.37 [17]; 3.03 [18].

Melting Point: -73 °C [19]; -84.8 °C [20]; -87.1 °C [2].

Solubility in Organics: Soluble in acetone, ethanol, chloroform, and ether [21].

Solubility in Water: 1,100 mg/L at 25 °C [22]; 1,100 mg/L at 20 °C [23]; 1,470 mg/L at 25 °C [24]; 0.0104 M at 25 °C [18]; 0.1 wt% at 20 °C [7]; 0.07 vol% at 20 °C [25]; 1,080 mg/L at 20 °C [26]; 0.137 wt% at 25 °C [27]; 1,250 mg/L at 60 °C [2].

Specific Density: 1.4642 at 20/4 °C [19]; 1.461 at 20/4 °C [28]; 1.375 at 100/4 °C [2].

Transformation Products: Microbial degradation by sequential dehalogenation may produce *cis*-1,2-dichloroethylene, *trans*-1,2-dichloroethylene, and vinyl chloride [29]. In a methanogenic aquifer, biodegradation produced 1,2-dichloroethylene and vinyl chloride [30].

Vapor Density: 5.37 g/L at 25 °C, 4.54 (air = 1).

Vapor Pressure: 5.4 mm at -20 °C, 10.8 mm at -10.8 °C, 20.1 mm at 0 °C, 35.2 mm at 10 °C, 57.8 mm at 20 °C, 94 mm at 30 °C, 146.8 mm at 40 °C, 212 mm at 50 °C, 305.7 mm at 60 °C, 760 mm at 86.7 °C [2]; 74 mm at 25 °C [31]; 1 mm at -43.8 °C, 10 mm at -12.4 °C, 40 mm at 11.9 °C, 100 mm at 31.4 °C, 400 mm at 67.0 °C, 760 mm at 86.7 °C [19]; 58 mm at 20 °C [10]; 57.9 mm at 20 °C [4]; 100 mm at 32 °C [32]; 53.5 mm at 20 °C [26]; 26.5 mm at 5 °C, 56.8 mm at 20 °C, 72.6 mm at 25 °C, 91.5 mm at 30 °C [33].

FIRE HAZARDS

Flash Point: 32.2 °C [34].

526 Trichloroethylene

Lower Explosive Limit (LEL): 8% [35].

Upper Explosive Limit (UEL): 10.5% [35].

HEALTH HAZARD DATA

Immediately Dangerous to Life or Health (IDLH): 1,000 ppm (carcinogen) [34].

Permissible Exposure Limits (PEL) in Air: 100 ppm, 200 ppm ceiling, 300 ppm 5 minute/2-hour peak [36]; 25 ppm 10-hour time weighted average [7]; 50 ppm ($\approx 270 \text{ mg/m}^3$), 200 ppm ($\approx 1,080 \text{ mg/m}^3$) STEL [37].

MANUFACTURING

Selected Manufacturers:

Dow Chemical Co.
Midland, MI 48640

E.I. duPont de Nemours and Co.
Electrochemicals Department
Wilmington, DE 19898

PPG Industries Inc.
Industrial Chemicals Division
Lake Charles, LA 70601

Uses: Dry cleaning fluid; degreasing and drying metals and electronic parts; extraction solvent for oils, waxes, and fats; solvent for cellulose esters and ethers; removing caffeine from coffee; refrigerant and heat exchange liquid; fumigant; diluent in paints and adhesives; textile processing; aerospace operations (flushing liquid oxygen); anesthetic; medicine; organic synthesis.

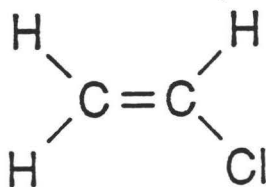
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VINYL CHLORIDE

Synonyms: Chlorethene; Chlorethylene; Chloroethene; 1-Chloroethene; Chloroethylene; 1-Chloroethylene; Ethylene monochloride; Monochloroethene; Monochloroethylene; MVC; RCRA waste number 0043; Trovidur; UN 1086; VC; VCM; Vinyl C monomer; Vinyl chloride monomer.

Structural Formula:



CHEMICAL DESIGNATIONS

CAS Registry Number: 75-01-4

DOT Designation: 1086

Empirical Formula: $\text{C}_2\text{H}_3\text{Cl}$

Formula Weight: 62.50

RTECS Number: KU 9625000

PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Colorless liquified compressed gas with a faint, sweetish odor.

Boiling Point: -13.4°C [1].

Henry's Law Constant: $2.78 \text{ atm}\cdot\text{m}^3/\text{mol}$ [2]; $0.022 \text{ atm}\cdot\text{m}^3/\text{mol}$ [3]; $2.37 \text{ atm}\cdot\text{m}^3/\text{mol}$ [4]; $1.22 \text{ atm}\cdot\text{m}^3/\text{mol}$ at 10°C [5]; $0.056 \text{ atm}\cdot\text{m}^3/\text{mol}$ at 25°C [6].

Ionization Potential: 9.995 eV [7].

Log K_{oc} : 0.39 using method of Karickhoff and others [8].

Vinyl chloride

Log K_{ow} : 0.60 [9].

Melting Point: -153.8 °C [1].

Solubility in Organics: Soluble in ethanol, carbon tetrachloride, and ether [10].

Solubility in Water: 1,100 mg/L at 25 °C [11]; 60 mg/L at 10 °C [12]; 2,700 mg/L at 25 °C [5]; 0.95 wt% at 15 °C, 0.995 wt% at 16 °C, 0.915 wt% at 20.5 °C, 0.88 wt% at 26 °C, 0.89 wt% at 29.5 °C, 0.94 wt% at 35 °C, 0.89 wt% at 41 °C, 0.88 wt% at 46.5 °C, 0.95 wt% at 55 °C, 0.92 wt% at 65 °C, 0.98 wt% at 72.5 °C, 1.00 wt% at 80 °C, 1.12 wt% at 85 °C [13].

Specific Density: 0.9106 at 20/4 °C [1]; 0.969 at -13/4 °C [14]; 0.94 at 13.9/4 °C, 0.9121 at 20/4 °C [15].

Transformation Products: Irradiation of vinyl chloride in the presence of nitrogen dioxide for 160 minutes produced formic acid, hydrochloric acid, carbon monoxide, formaldehyde, and ozone. Trace amounts of formyl chloride and nitric acid were also identified. In the presence of ozone, however, vinyl chloride photooxidized to carbon monoxide, formaldehyde, formic acid, and small amounts of hydrochloric acid [16].

Vapor Density: 2.86 g/L at 0 °C [17]; 2.55 g/L at 25 °C, 2.16 (air = 1).

Vapor Pressure: 240 mm at -40 °C; 580 mm at -20 °C, 2,660 mm at 25 °C [11]; 2,580 mm at 20 °C [18]; 1 mm at -105.6 °C, 10 mm at -83.7 °C, 40 mm at -66.8 °C, 100 mm at -53.2 °C, 400 mm at -28.0 °C, 760 mm at -13.8 °C [1]; 2,530 mm at 20 °C [19]; 2,600 at 25 °C [20]; 0.50 atm at -30 °C, 0.77 atm at -20 °C, 1.17 atm at -10 °C, 1.70 atm at 0 °C, 2.43 atm at 10 °C, 3.33 atm at 20 °C, 4.51 atm at 30 °C, 5.94 atm at 40 °C, 7.20 atm at 50 °C, 9.93 atm at 60 °C [15]; 2,320 mm at 20 °C [21].

FIRE HAZARDS

Flash Point: -78 °C [7].

Lower Explosive Limit (LEL): 3.6% [7].

Upper Explosive Limit (UEL): 33% [7].

Vinyl chloride

HEALTH HAZARD DATA

Immediately Dangerous to Life or Health (IDLH): Potential human carcinogen [7].

Permissible Exposure Limits (PEL) in Air: 1 ppm, 5 ppm 15-minute ceiling [22]; lowest detectable limit [7]; 5 ppm ($\approx 10 \text{ mg/m}^3$) [19].

MANUFACTURING

Selected Manufacturers:

Dow Chemical Co.
Midland, MI 48640

Uses: Manufacturing of polyvinyl chloride and copolymers; adhesives for plastics; refrigerant; extraction solvent; organic synthesis.

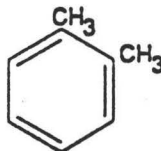
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7. "NIOSH Pocket Guide to Chemical Hazards," U.S. Department of Health and Human Services, U.S. Government Printing Office

o-XYLENE

Synonyms: 1,2-Dimethylbenzene; *o*-Dimethylbenzene; *o*-Methyltoluene;
UN 1307; 1,2-Xylene; ortho-Xylene; *o*-Xylol.

Structural Formula:



CHEMICAL DESIGNATIONS

CAS Registry Number: 95-47-6

DOT Designation: 1307

Empirical Formula: C_8H_{10}

Formula Weight: 106.17

RTECS Number: ZE 2450000

PHYSICAL AND CHEMICAL PROPERTIES

Appearance: Clear, colorless liquid.

Boiling Point: 144.4 °C [1]; 143-144 °C [2].

Henry's Law Constant: 0.00527 atm·m³/mol [3]; 0.0050 atm·m³/mol [4];
0.00535 atm·m³/mol at 25 °C [5].

Ionization Potential: 8.56 eV [6].

Log K_{ow} : 2.11 [7].

Log K_{ow} : 2.95 [8]; 3.13 [9]; 2.77 [10]; 3.16 [11]; 3.08 [12].

Melting Point: -25.2 °C [1].

Solubility in Organics: Soluble in acetone, ethanol, benzene, and ether
[1].

***o*-Xylene**

Solubility in Water: 152 mg/L at 20 °C [13]; 200 mg/L [8]; 204 mg/L at 25 °C [14]; 175 mg/L at 25 °C [3]; 0.00208 M at 25 °C [9]; 142 mg/L at 0 °C, 167 mg/L at 25 °C [15]; 142 ppm at 0 °C, 213 ppm at 25 °C [16]; 170.5 ppm at 25 °C, 129.6 ppm in artificial seawater at 25 °C [17]; 176.2 mg/L at 25 °C [18]; 1,742 mmols/L at 20 °C [12].

Specific Density: 0.8802 at 20/4 °C [1]; 0.88011 at 20/4 °C [19]; 0.87596 at 25/4 °C [20].

Transformation Products: No data found.

Vapor Density: 4.34 g/L at 25 °C, 3.66 (air = 1).

Vapor Pressure: 1 mm at -9.8 °C, 10 mm at 25.9 °C, 40 mm at 52.8 °C, 100 mm at 74.1 °C; 400 mm at 113.8 °C; 760 mm at 136.2 °C [1]; 6.6 mm at 25 °C [3].

FIRE HAZARDS

Flash Point: 17 °C [21]; 46.1 °C (open cup) [22].

Lower Explosive Limit (LEL): 1% [6].

Upper Explosive Limit (UEL): 6% [6].

HEALTH HAZARD DATA

Immediately Dangerous to Life or Health (IDLH): 1,000 ppm (isomeric mixture) [6].

Permissible Exposure Limits (PEL) in Air: For total xylenes (containing *ortho*, *meta* and *para* isomers) - 100 ppm (≈ 435 mg/m³) [23]; 100 ppm, 150 ppm (≈ 655 mg/m³) STEL [24].

MANUFACTURING

Selected Manufacturers:

ARCO Chemical Co.
260 South Broad St.
Philadelphia, PA 19101

***o*-Xylene**

Cities Services Co., Inc.
Petrochemicals Division
60 Wall St.
New York, NY 10005

Shell Chemical Co.
Petrochemicals Division
Houston, TX 77001

Uses: Preparation of phthalic acid, phthalic anhydride, terephthalic acid, isophthalic acid; solvent for alkyd resins, lacquers, enamels, rubber cements; manufacturing of dyes, pharmaceuticals, and insecticides; motor fuels.

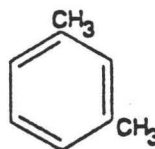
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9. Tewari, Y.B., Miller, M.M., Wasik, S.P., and D.E. Martire. "Aqueous Solubility and Octanol/Water Partition Coefficient of Organic

m-XYLENE

Synonyms: 1,3-Dimethylbenzene; *m*-Dimethylbenzene; *m*-Methyltoluene; UN 1307; 1,3-Xylene; *m*-Xylol.

Structural Formula:



CHEMICAL DESIGNATIONS

CAS Registry Number: 108-38-3

DOT Designation: 1307

Empirical Formula: C_8H_{10}

Formula Weight: 106.17

RTECS Number: ZE 2275000

PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Clear, colorless, watery liquid with a sweet odor.

Boiling Point: 139.1 °C [1]; 137-138 °C [2].

Henry's Law Constant: 0.0070 atm·m³/mol [3]; 0.0063 atm·m³/mol at 25 °C [4].

Ionization Potential: 8.58 eV [5].

Log K_{oc} : 3.20 [6].

Log K_{ow} : 3.20 [7].

Melting Point: -47.9 °C [1].

Solubility in Organics: Soluble in acetone, ethanol, benzene, and ether [1].

m-Xylene

Solubility in Water: 158 mg/L [8]; 173 mg/L at 25 °C [9]; 0.00151 M at 25 °C [10]; 0.0146 wt% at 25 °C [11]; 196 ppm at 0 °C, 162 ppm at 25 °C [12]; 146.0 ppm at 25 °C, 106.0 ppm in artificial seawater at 25 °C [13]; 157.0 mg/L at 25 °C [14]; 1,525 mmols/L at 20 °C [15]; 170 ppm at 25 °C [16].

Specific Density: 0.8642 at 20/4 °C [1]; 0.8684 at 25/4 °C [17]; 0.86407 at 20/4 °C, 0.85979 at 25/4 °C [18].

Transformation products: Microbial degradation produced 3-methylbenzyl alcohol, 3-methylbenzaldehyde, *m*-toluic acid, and 3-methylcatechol [19].

Vapor Density: 4.34 g/L at 25 °C, 3.66 (air = 1).

Vapor Pressure: 1 mm at -6.9 °C, 10 mm at 28.3 °C, 40 mm at 55.3 °C, 100 mm at 76.8 °C; 400 mm at 116.7 °C; 760 mm at 139.1 °C; [1]; 8.287 at 25 °C [20]; 15.2 at 35 °C [21].

FIRE HAZARDS

Flash Point: 25 °C [5].

Lower Explosive Limit (LEL): 1.1% [5].

Upper Explosive Limit (UEL): 7% [5].

HEALTH HAZARD DATA

Immediately Dangerous to Life or Health (IDLH): 1,000 ppm (isomeric mixture) [5].

Permissible Exposure Limits (PEL) in Air: For total xylenes (containing *ortho*, *meta* and *para* isomers) - 100 ppm (≈ 435 mg/m³) [22]; 100 ppm, 150 ppm (≈ 655 mg/m³) STEL [23].

MANUFACTURING

Selected Manufacturers:

ARCO Chemical Co.
260 South Broad St.
Philadelphia, PA 19101

m-Xylene

Chevron Chemical Co.
Industrial Chemicals Division
200 Bush St.
San Francisco, CA 94120

Fallek Chemical Corp.
460 Park Ave.
New York, NY 10022

Uses: Solvent; intermediate for dyes and organic synthesis; insecticides; aviation fuel.

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3. Pankow, J.F., and M.E. Rosen. "Determination of Volatile Compounds in Water by Purging Directly to a Capillary Column with Whole Column Cryotrapping," *Environ. Sci. Technol.*, 22(4):398-405 (1988).
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APPENDIX D

PHOTOGRAPHS



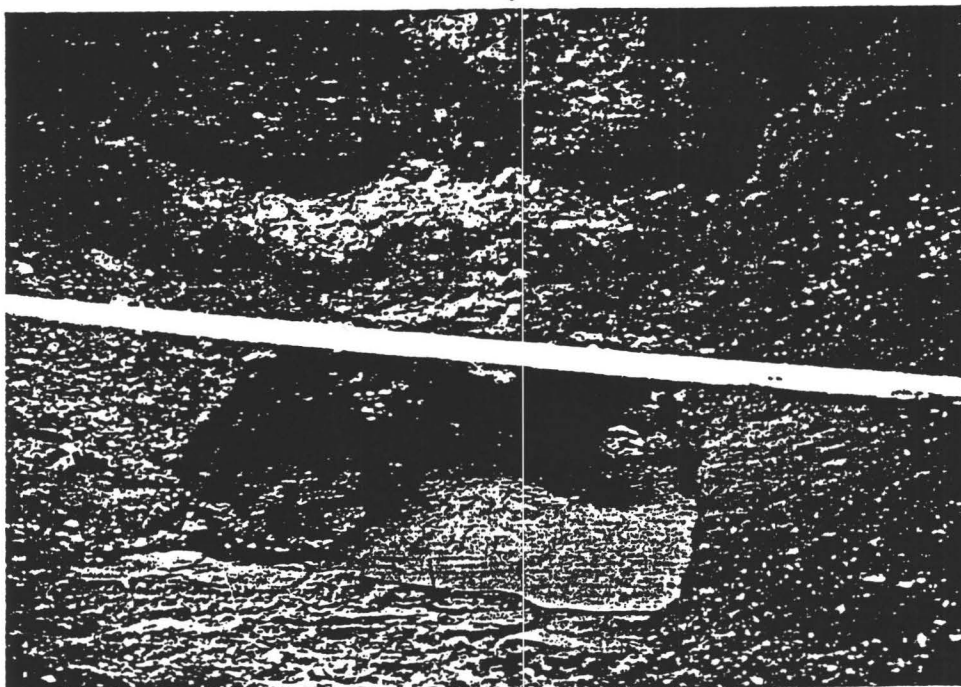
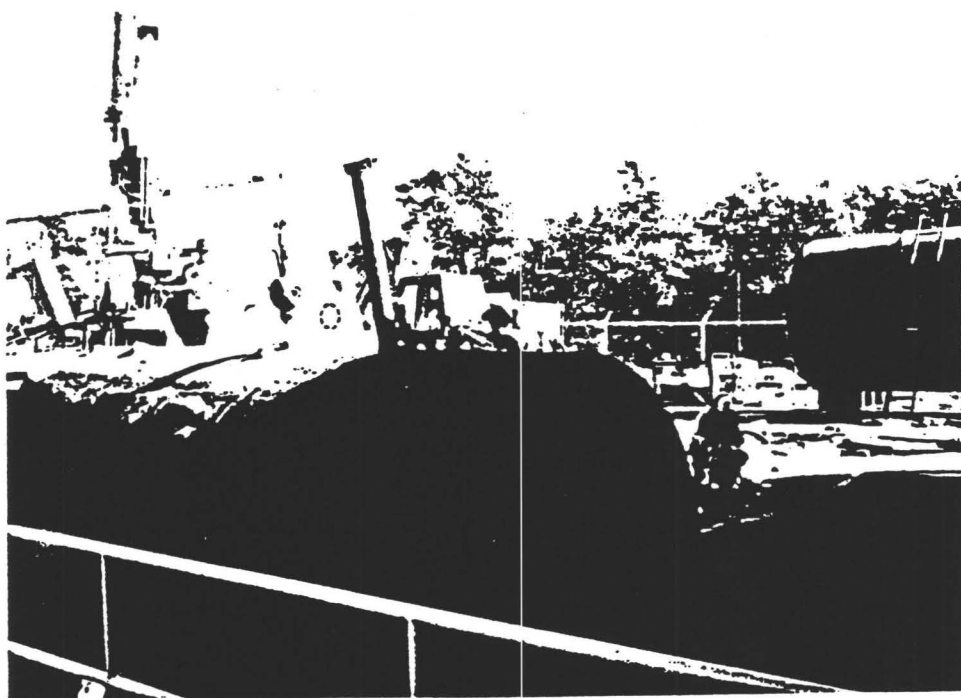
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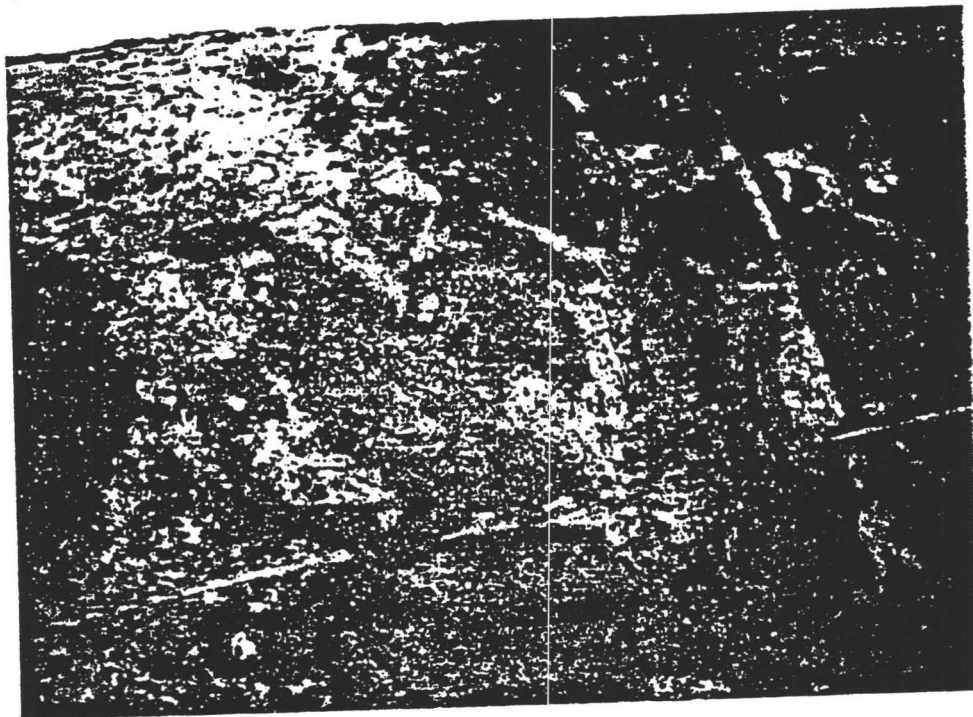
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Pumping of Seepage Liquids
(Rec-Tank-Liquid Storage)



Tank 1
Removal

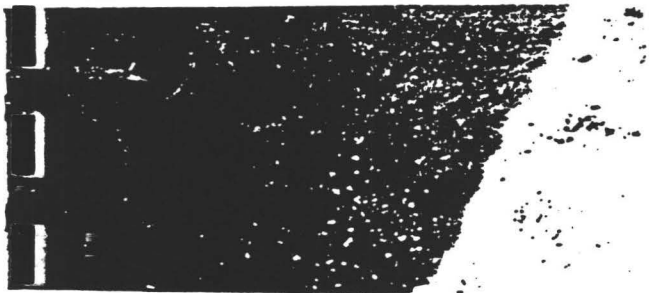
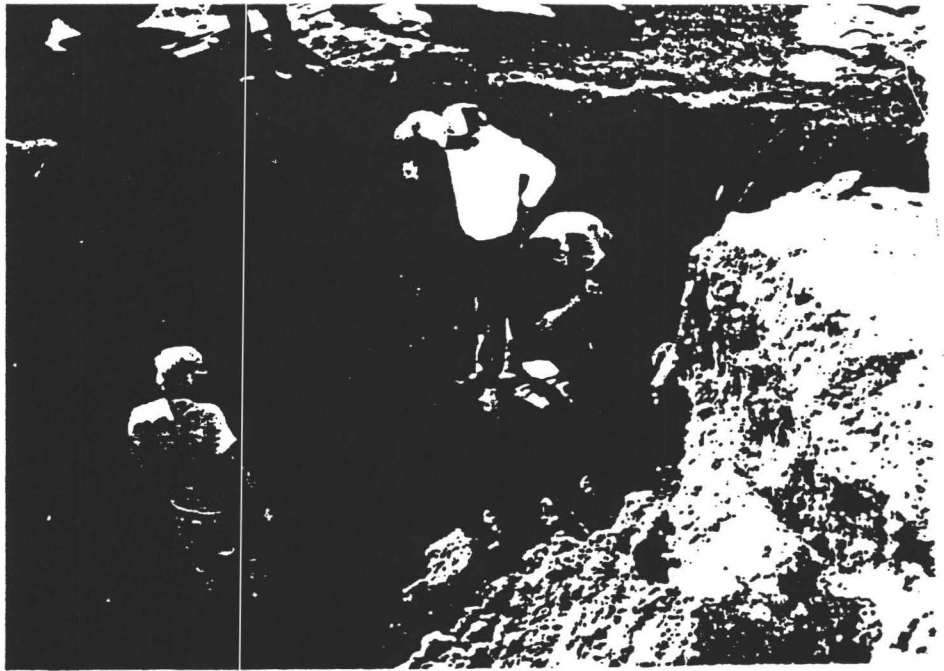


Tank 1
Seepage Liquids
Foreground-New pipeline



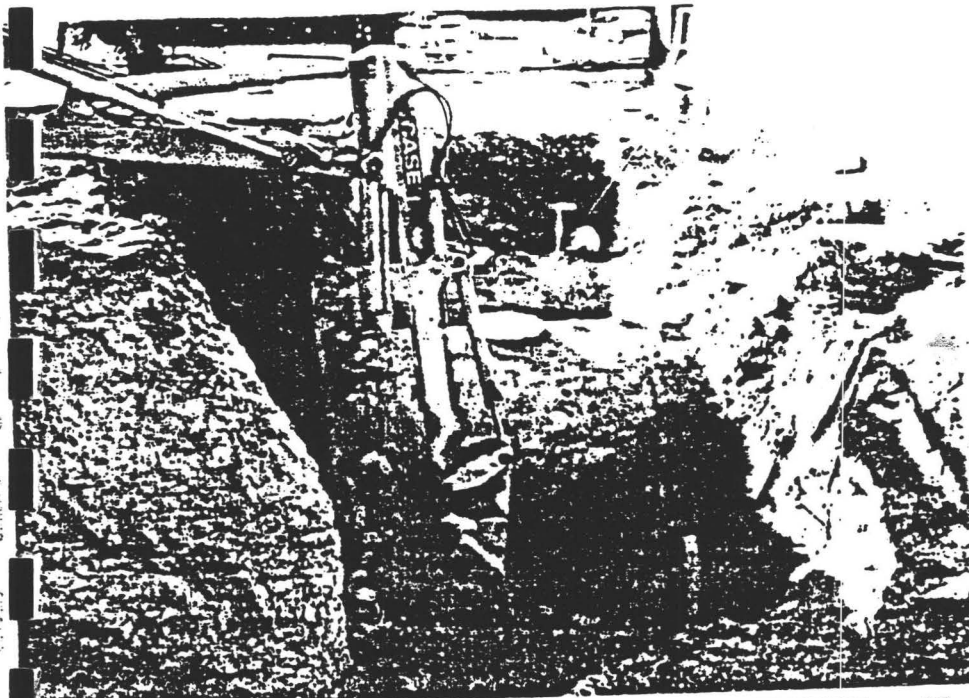
Tank 1
Corrosion Holes

Tank 2
Excavation

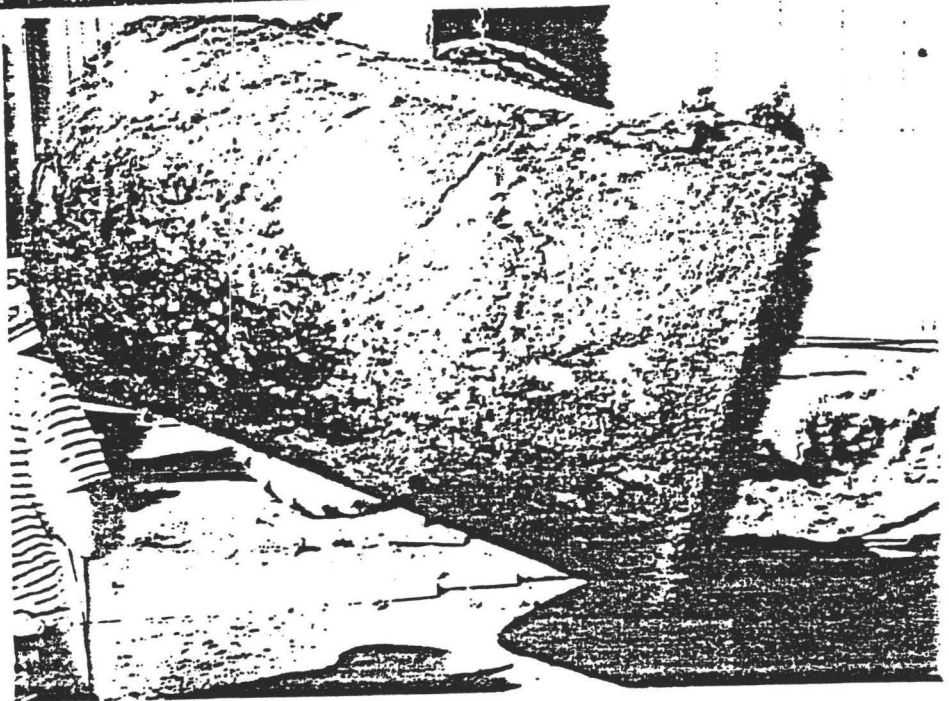


Tanks 2 and 3
Excavation





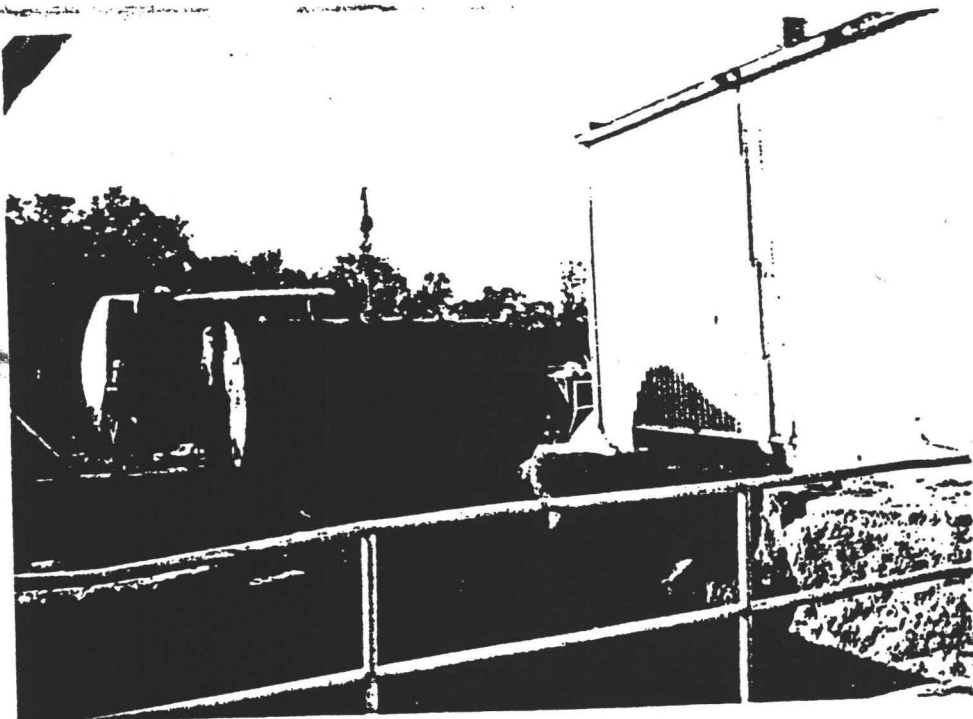
tanks 2 and 3
Seepage Liquid Removal



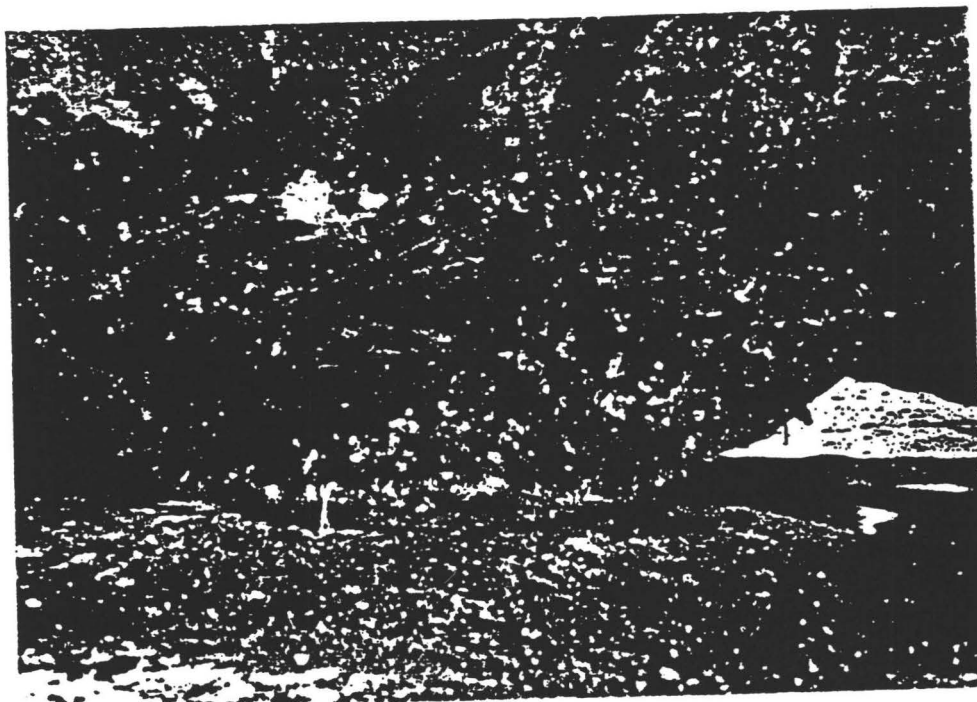
Tank 2
Removal



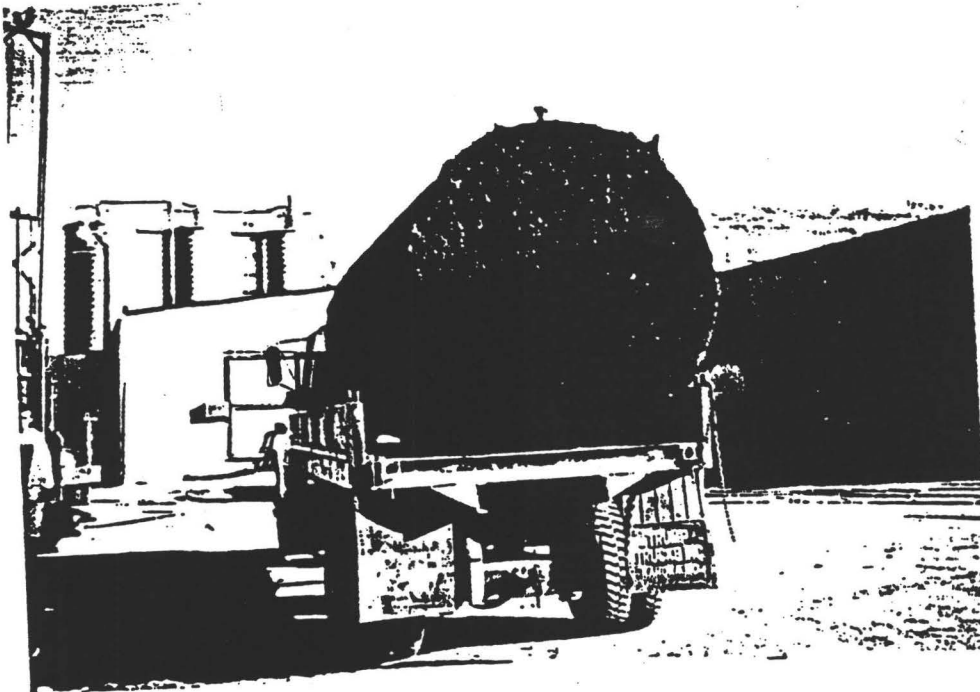
Tank 3
Corrosion and Pitting



Tank 4
Removal

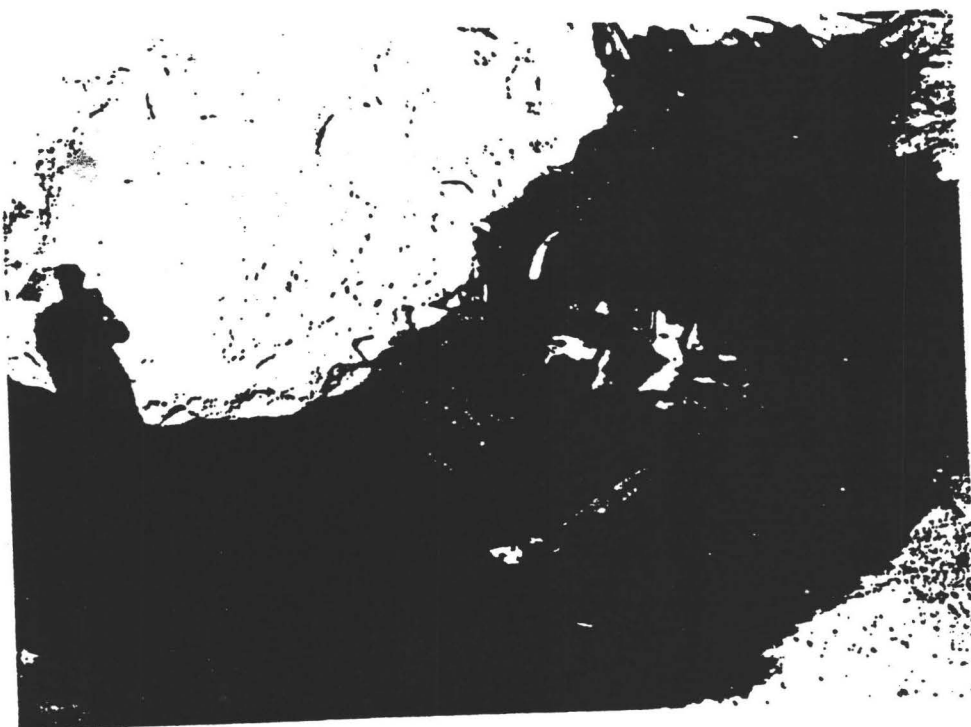


Tank 4
Corrosion and Leaking

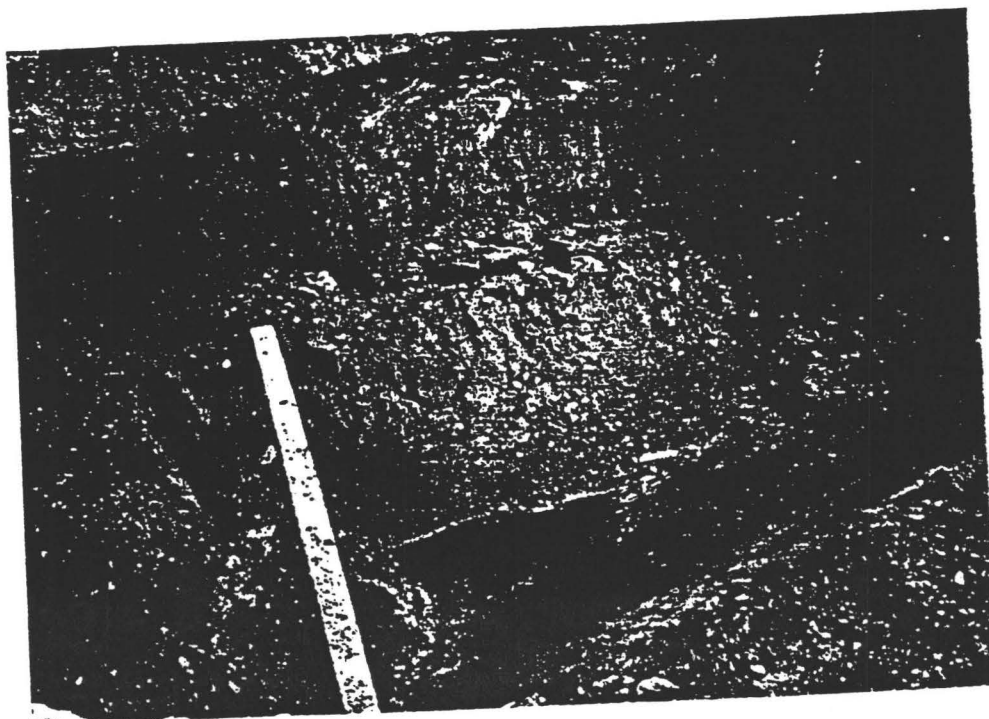


Tank 5
Removal

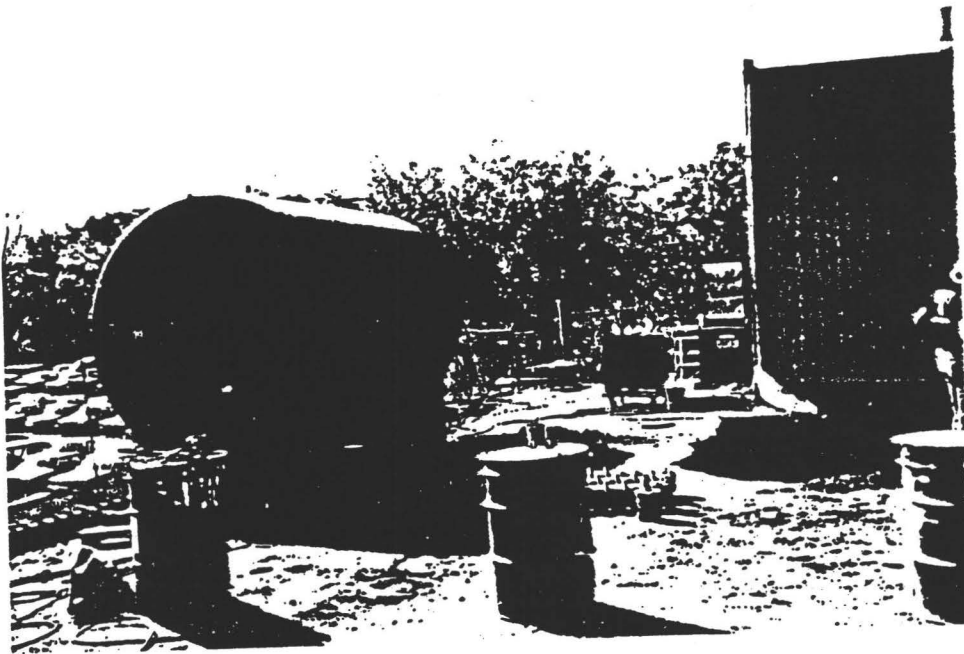




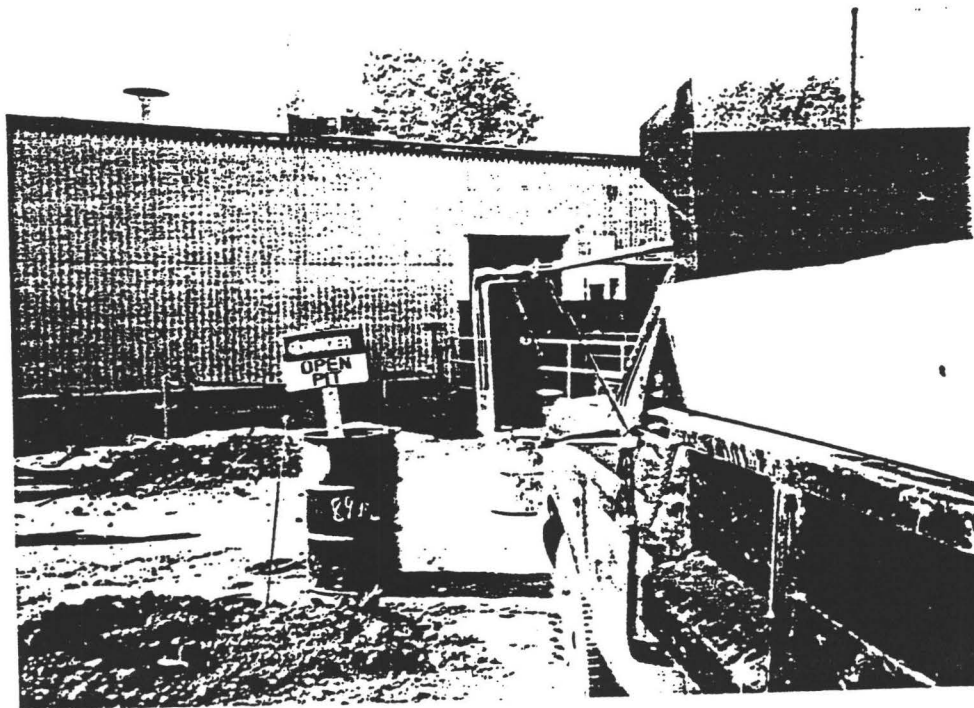
Excavation
Showing Seepage Liquids
after pumping



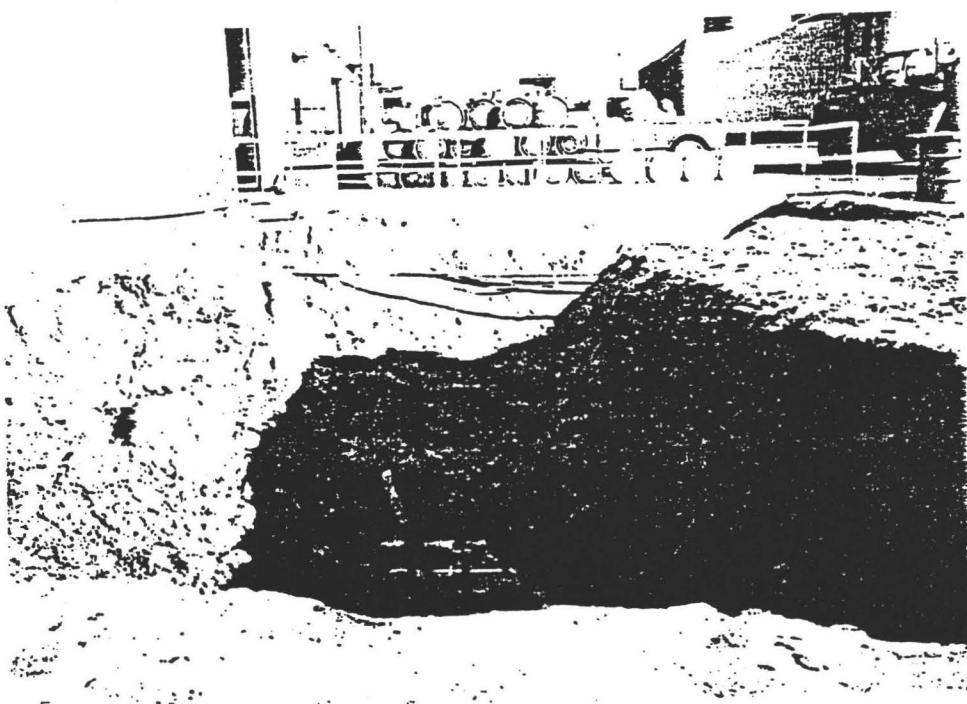
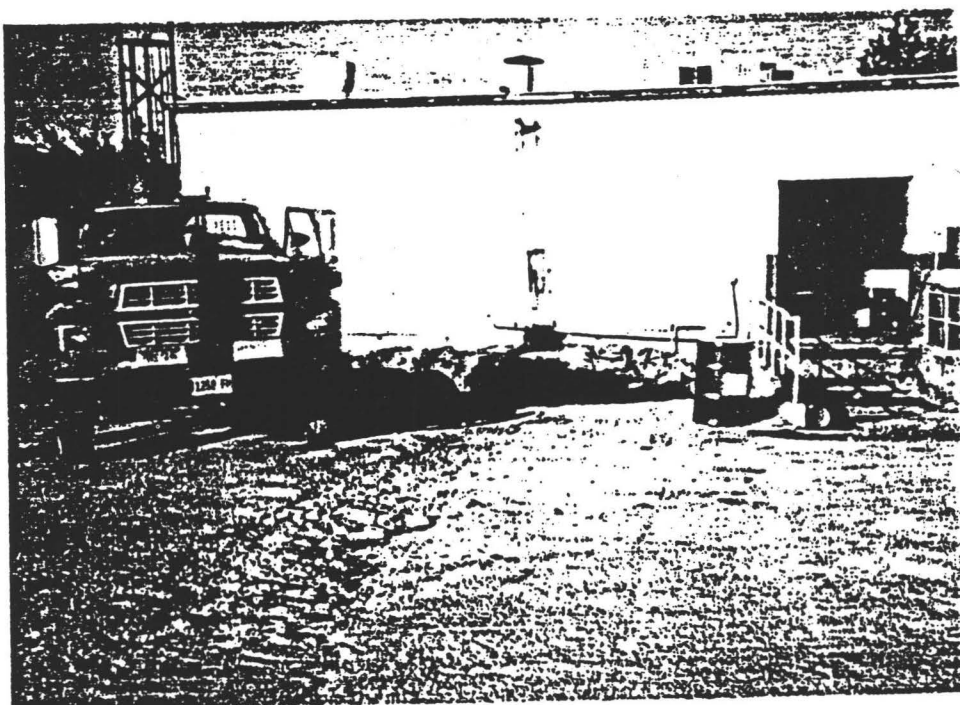
Tank 5
Seepage Liquids



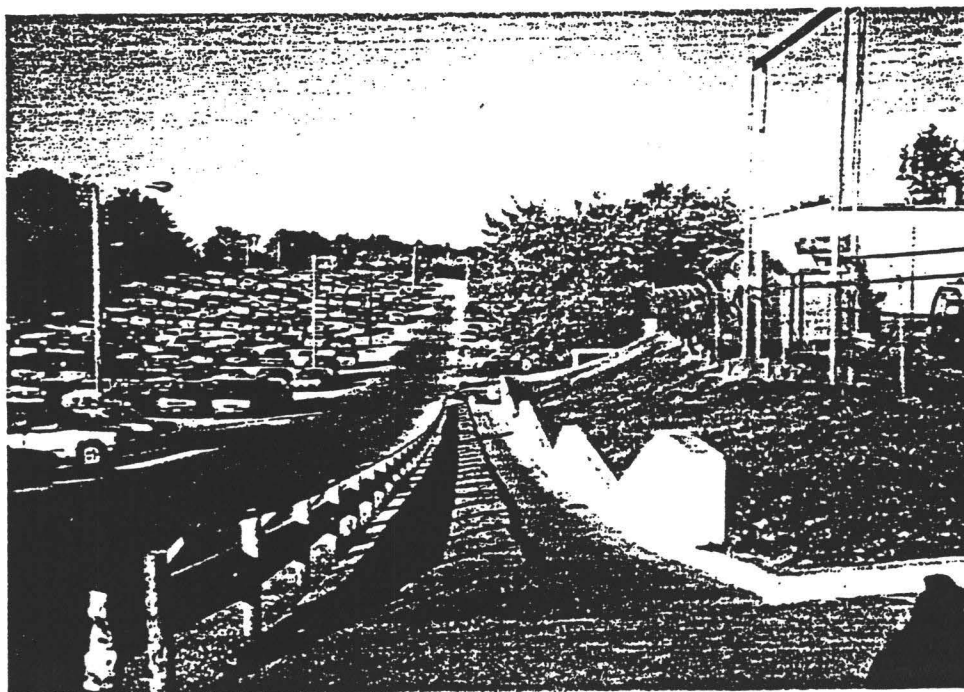
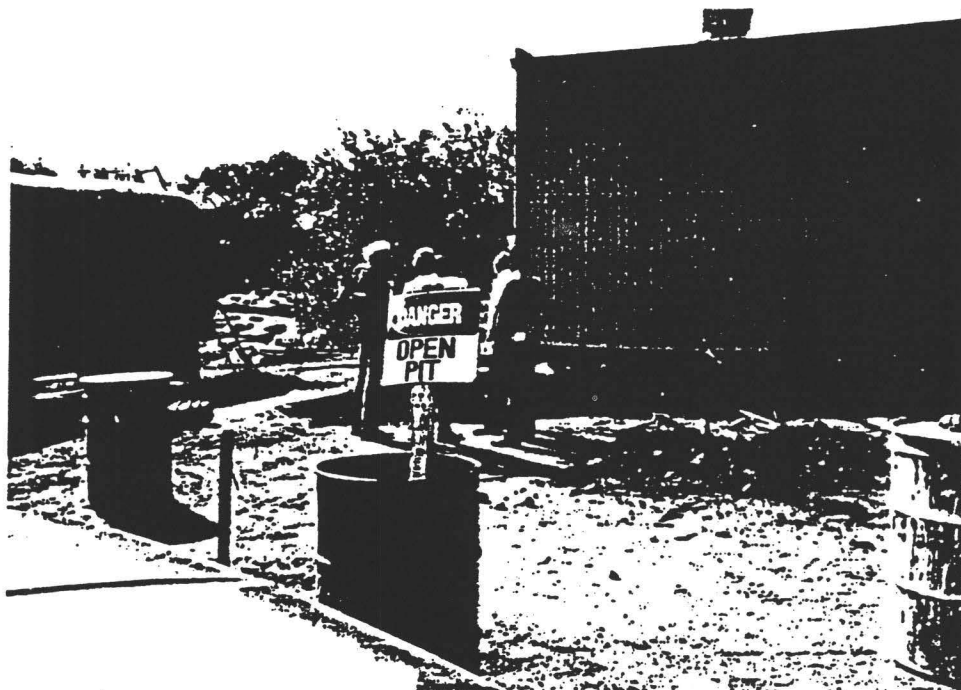
Temporary Storage Tank
Looking South
Blue flag indicates well loc.



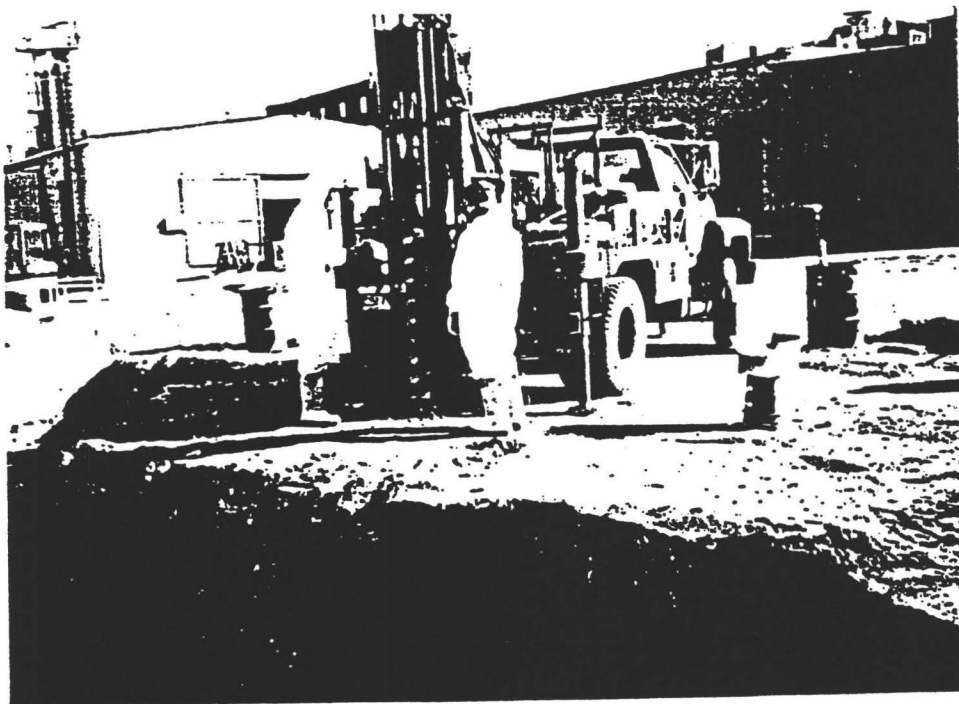
Excavation (South)
Mixing building in background
Blue flags indicate well loc.



Excavation
from East side



East end of Plant
(excavation to immediate right)



Monitoring Well Installation

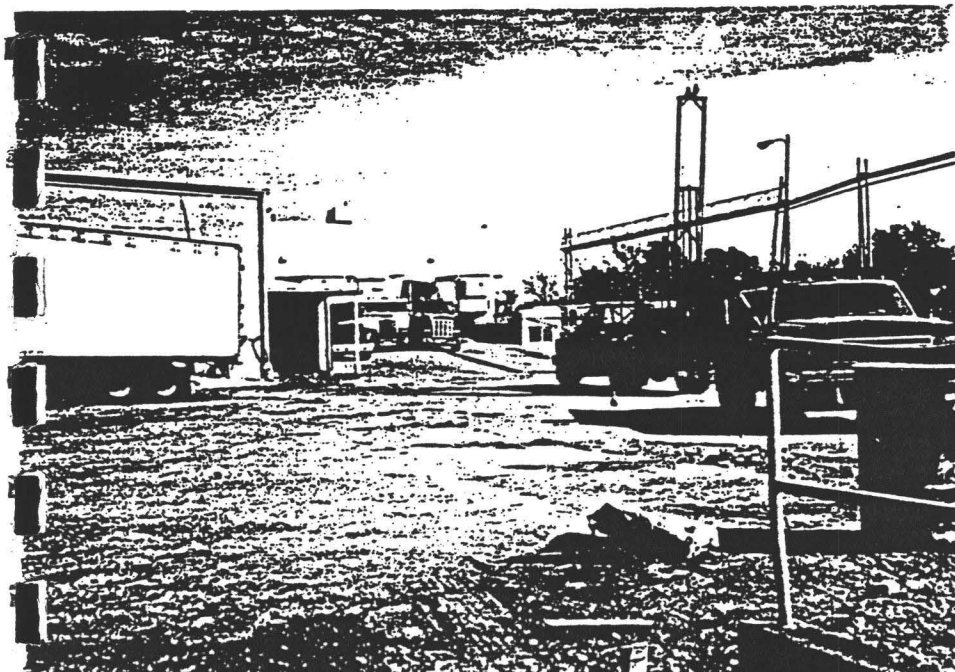


Photoionization Detector
(uses in excavation to
determine volatile concen-
trations)

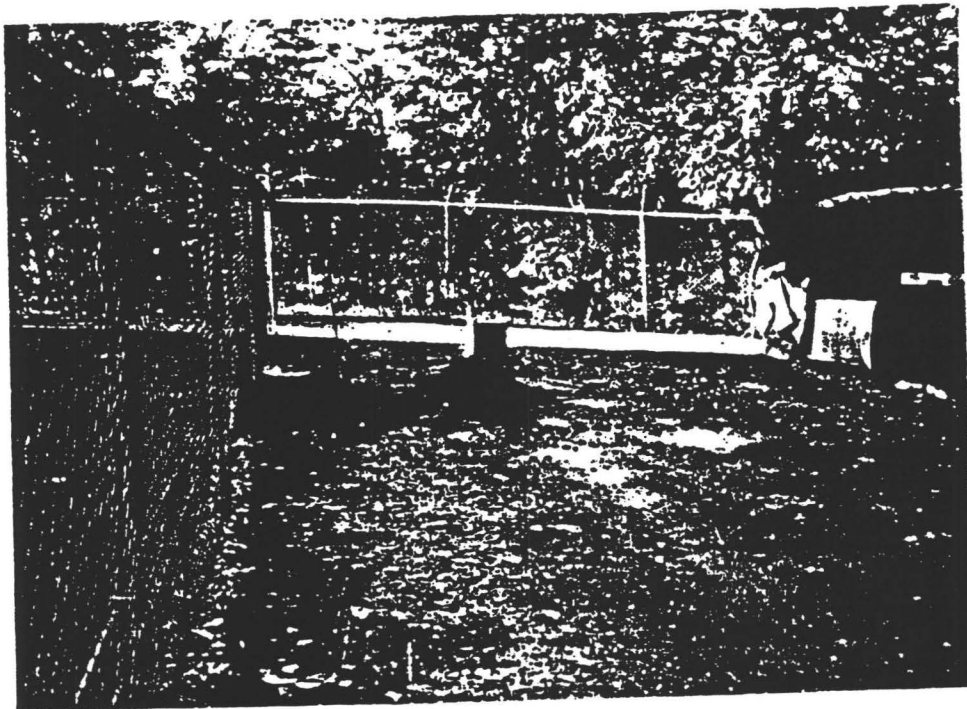


Pipeline
Looking North from Excavation
flags indicate boring loc.

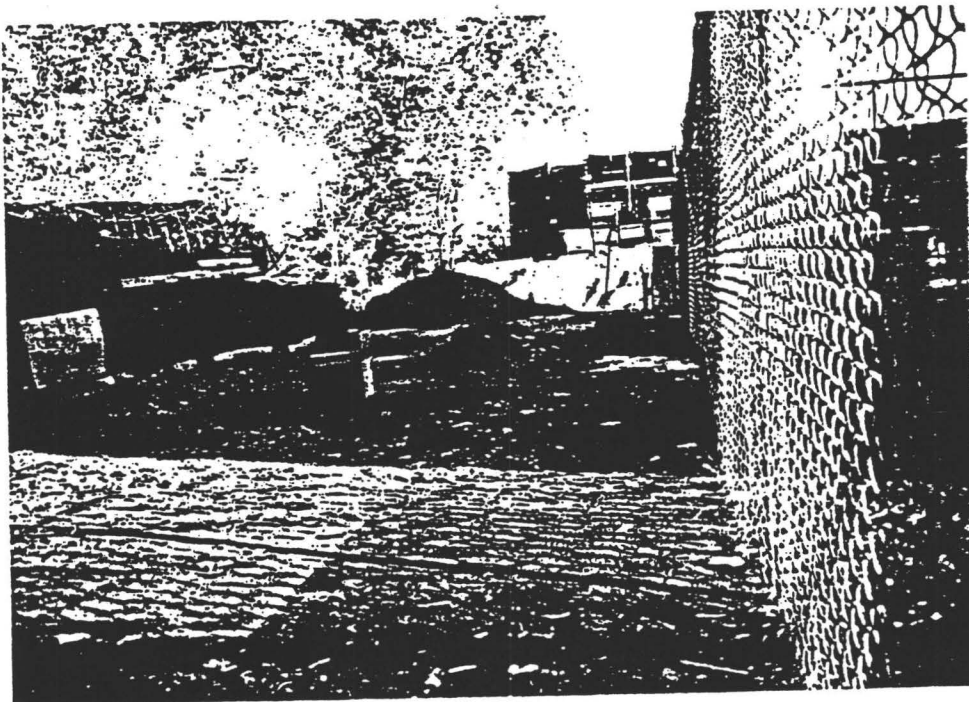
Pipeline
looking South from Main Bldg.
flags indicate boring loc.



Pipeline
Looking from mixing Bldg. Ramy



Monitoring Well located to
South of chemical mixing
Bldg looking East.



Monitoring Well behind mixing
Bldg. looking West



Looking East from bottom
of fill area



South Property and Lake to
South of Excavation



Immediate Southern Area from
excavation (Backwaters from
Lake)



Drainage from
Plant to Lake

APPENDIX E

BORING LOGS, MONITORING WELL DIAGRAMS

Randoipn & Associates Field Boring Log

Boring No. B-1

Date 10-12-89

Project Name Sheller Globe Location Keokuk, Iowa Job. No. 1-0993-004-01

Geologist E. Sloneker Drilling Contractor Whitney & Assoc Driller Tim Fehl

Seepage

Water: Depth Encountered _____ Depth at Completion _____ Total Depth of Boring 15'

Sample Number	Sample Interval	Sample Method	Blows	HNU (ppm)	Depth	Description	Symbol
	0-2	auger				Black and Gray Asphalt over gravel base	
	2-4	SS				Black and gray silty clay fill with little sand, gravel, brick frags, and rubber	
	4-6	SS			5	Black and gray silty clay fill with little sand, gravel, brick and concrete fragments.	
	6-8	SS				Upper 6" as above soil below till. Brownish green silty clay with common Fe Concreations, dark gray clay coats along Ped faces & fractures, little sand	
	8-10	SS			10	Same fill soil as above, coarse black sandy silt below, strong odor, abundant brick frags.	
	10-12	SS				Greenish brown silty clay with common sand, bricks and concrete frags.	
	12-14	SS				Upper 4" is fill as before, brown & gray silty clay till with abundant sand & gravel, strong Pedogenic development, light gray clay coats along	
	14-16	SS			15	Till as above	
					20		
					25		
					30		

Randolph & Associates Field Boring Log

Boring No. B-2

Date 10-12-89

Project Name Sheller Globe Location Keokuk, Iowa Job. No. 1-0993-004-01

Geologist E. Sloneker Drilling Contractor Whitney Driller Tim Fehl

Water: Depth Encountered _____ Depth at Completion _____ Total Depth of Boring 16'

Sample Number	Sample Interval	Sample Method	Blows	HNU (ppm)	Depth	Description	Symbol
	0-5	auger				Brownish green silty clay with abundant sand, gravel, abundant wood, slag, metal pellets	
	5-7	SS			5	as above	
	7-10	Auger				Black silty clay fill with abundant sand, gravel, wood, ect.	
	10-12	SS			10	Black to browish green, as above	
	12-14	SS				Brownish green to black silty clay fill with abundant concrete, sand and gravel.	
	14-16	SS			15	Black till to 15', blue silty clay till below.	
					20		
					25		
					30		

Randolph & Associates Field Boring Log

Boring No. B-3

Date 10-12-89

Project Name Shelley Globe Location Keokuk, Iowa

Job. No. 1-0993-004-01

Geologist Al Green

Drilling Contractor Whitney

Driller Tim Fehl

Water: Depth Encountered _____

Depth at Completion _____

Total Depth of Boring 16'

Sample Number	Sample Interval	Sample Method	Blows	HNU (ppm)	Depth	Description	Symbol
1	1-4'	Auger				Gray silty gravel fill, poorly sorted sandy, irregular materials, slight odor.	
2	4-6	SS			5	Sample core not recovered. Dark black silty clay fill, irregular gravel clasts, slight odor.	
3	6-8	SS				Same as above few clasts, lighter color strong odor	
4	8-10	SS				Uncompacted layer. Gray silt clay fill, gravel clasts strong odor, oxidized.	
5	10-12	SS		225	10	Same as above, gravel-debris at 11.5' water seepage, strong odor present	
6	12-14	SS				Unrecovered core. wet, strong odor	
	14-16				15	Gray-blue Till. Well filling with free product.	
					20		
					25		
					30		

Randolph & Associates Field Boring Log

Boring No. B-4

Date 10-13-89

Project Name Sheller Globe Location Keokuk, Iowa Job. No. 1-0993-004-01

Geologist Al Green Drilling Contractor Whitney Driller Tim Fehl

Water: Depth Encountered _____ Depth at Completion _____ Total Depth of Boring 15.5'

Sample Number	Sample Interval	Sample Method	Blows	HNU (ppm)	Depth	Description	Symbol
1	1-4'	Auger				Black to gray silt fill, slight odor, gravels, debris.	
2	4-6	SS			5	Blue-gray silt clay fill, gravel, red brick debris, moist, strong odor.	
3	6-8'	SS				Same to 7' then 6" layer black silty gravel fill, wet strong odor at 7.5 blue-gray silty clay fill material moist, strong odor, oxidized, gravel clasts	
4	8-10	SS				Blue-gray silt clay fill, concrete debris, some wet layers, strong odor.	
5	10-12	SS			10	Blue-gray silty till, wet, poorly sorted irregular gravel clasts, strong odor. Slightly oxidized	
6	12-14	SS				Same as above. Blue-gray Till at 14' Strong odor.	
7	14.5- 5.5	SS			15	Brown-blue till, large clasts which are blue-gray in color, moist, strong odor.	
					20		
					25		
					30		

TELEPHONE
309 411 2131

TESTS
DESIGN
REPORTS
ANALYSIS
INSPECTION
CONSULTATION
INVESTIGATIONS

T. Fehl

INSTALLED BY



WHITNEY & ASSOCIATES

INCORPORATED

2406 West Nebraska Avenue
PEORIA, ILLINOIS 61604

SPECIALISTS IN

SOILS - PORTLAND CEMENT CONCRETE
STEEL - BITUMINOUS CONCRETE
CONSTRUCTION MATERIALS
AGGREGATES - ASPHALT - POZ-O-PAC

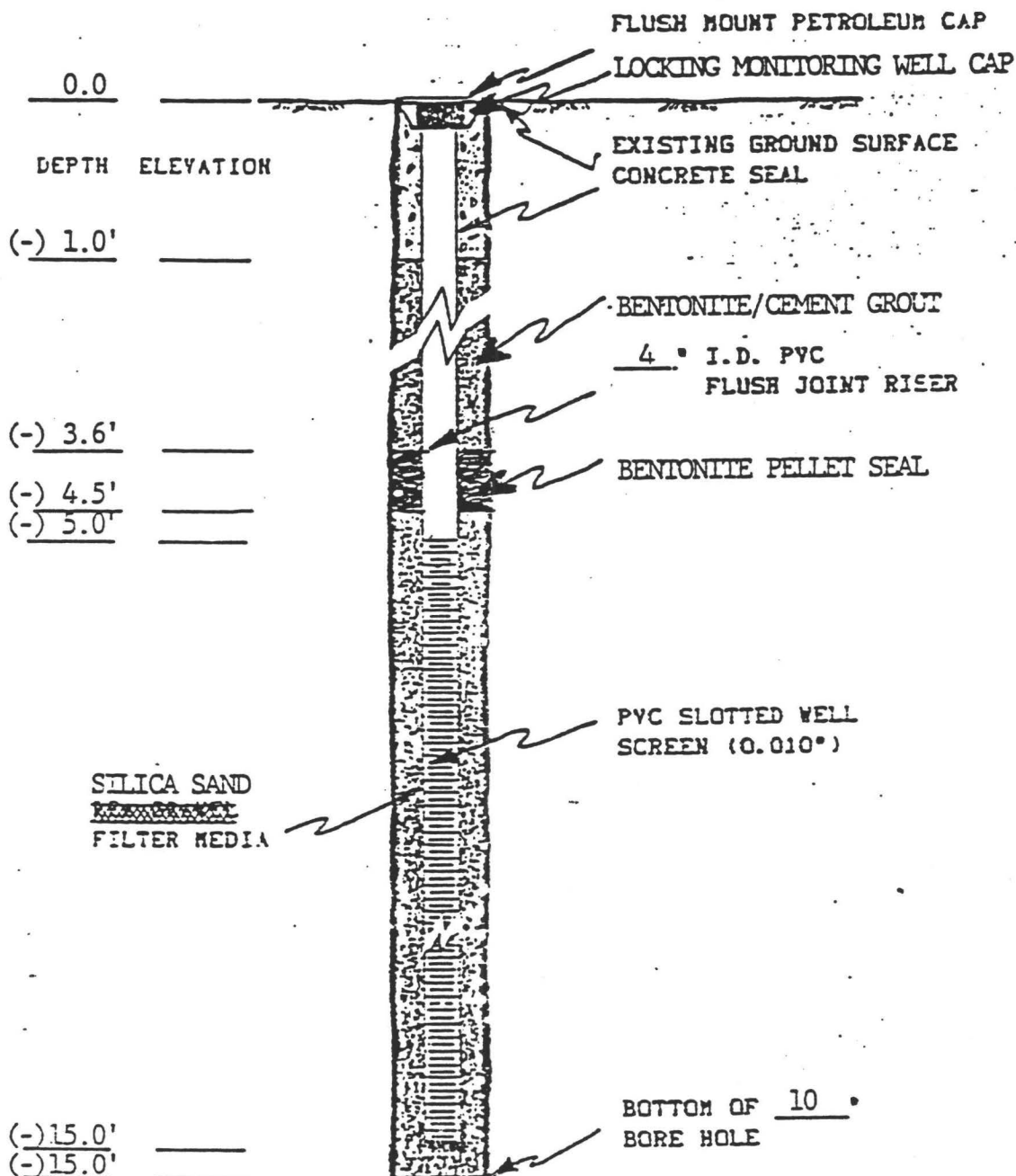
SOILS AND GRAVEL SURVEYS
MATERIALS QUALITY CONTROL
SOIL MECHANICS AND
FOUNDATION ENGINEERING
DRILLING - CORING - TESTING

10-12-89

DATE

TYPICAL MONITORING WELL DIAGRAM

PROJECT Scheller Globe Corporation MONITORING WELL NO. MW-1
LOCATION Keokuk, Iowa INSTALLATION DATE 10-12-89
MONITORING WELL LOCATION _____



BENCH MARK _____

WHITNEY & ASSOCIATES
PEORIA, ILLINOIS

TELEPHONE
309 673-2131

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CONSTRUCTION MATERIALS
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SOILS AND GRAVEL SURVEYS
MATERIALS QUALITY CONTROL
SOIL MECHANICS AND
FOUNDATION ENGINEERING
DRILLING - COMING - TESTING

10-12-89

DATE

TYPICAL MONITORING WELL DIAGRAM

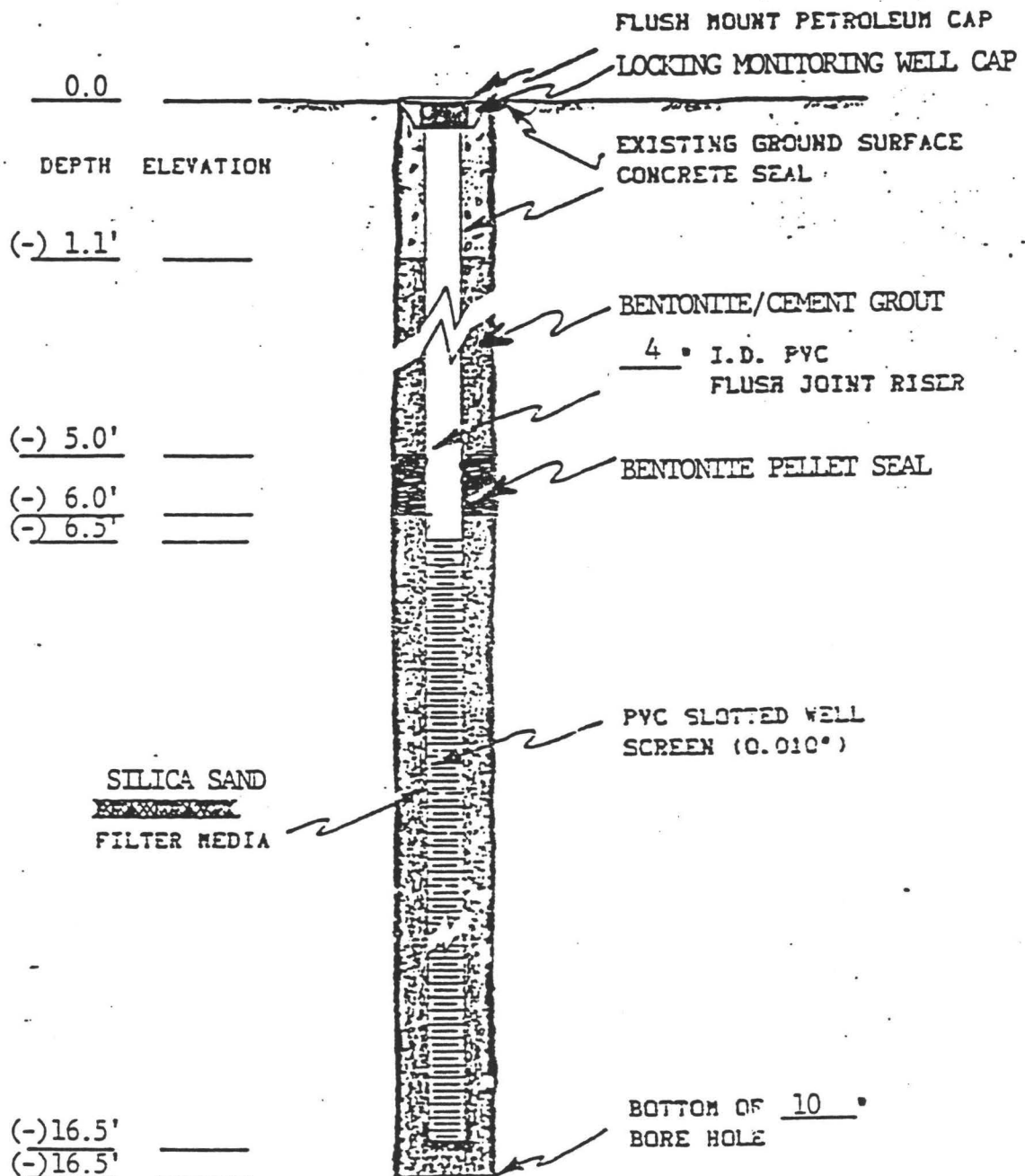
PROJECT Scheller Globe Corporation

MONITORING WELL NO. MW-2

LOCATION Keokuk, Iowa

INSTALLATION DATE 10-12-89

MONITORING WELL LOCATION _____



BENCH MARK _____

WHITNEY & ASSOCIATES
PEORIA, ILLINOIS

TELEPHONE
309 573-2131

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REPORTS
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STEEL - BITUMINOUS CONCRETE
CONSTRUCTION MATERIALS
AGGREGATES - ASPHALT - POZ-O-PAC

SOILS AND GRAVEL SURVEYS
MATERIALS QUALITY CONTROL
SOIL MECHANICS AND
FOUNDATION ENGINEERING
DRILLING - CORING - TESTING

10-13-89

DATE

TYPICAL MONITORING WELL DIAGRAM

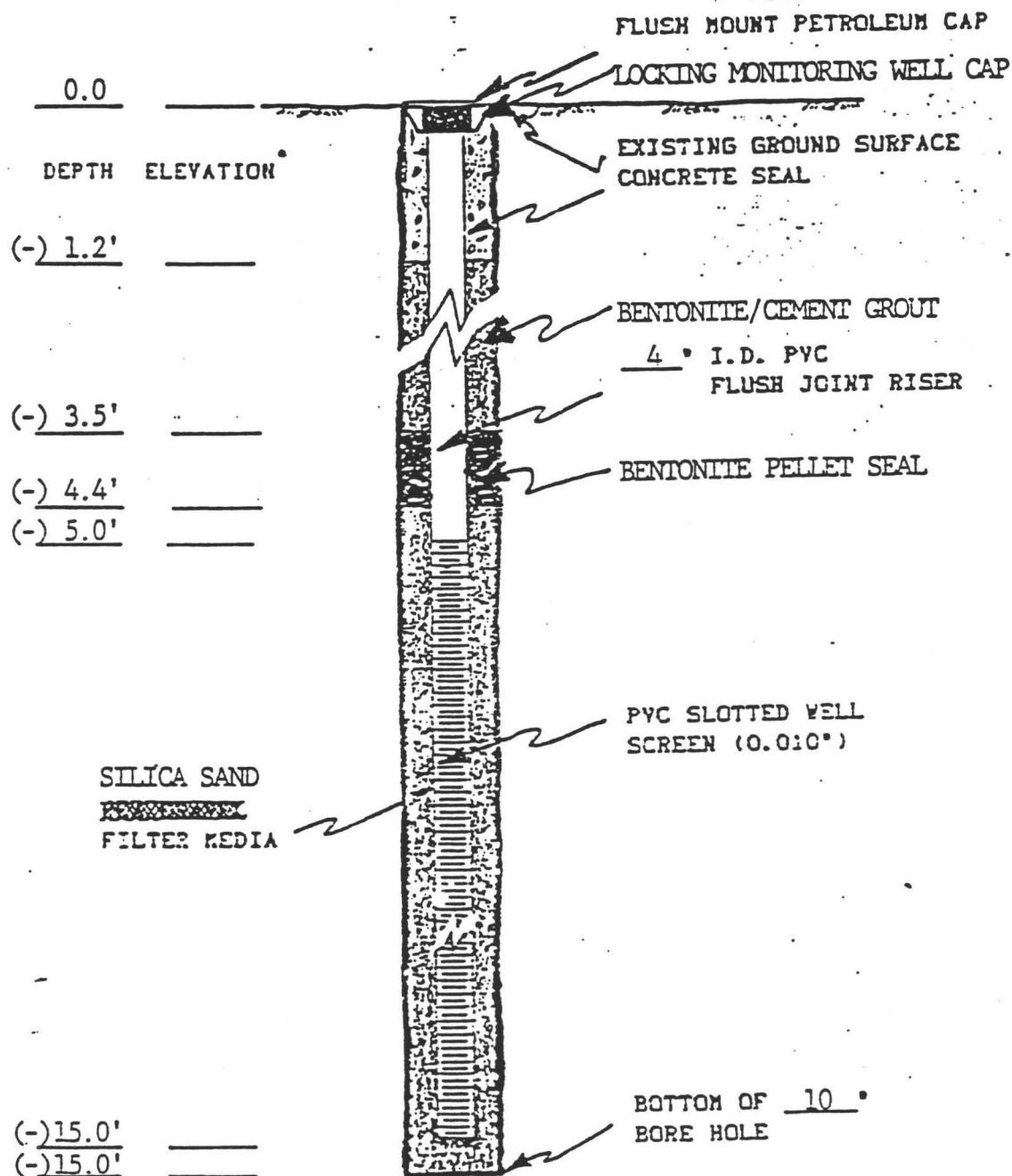
PROJECT Scheller Globe Corporation

MONITORING WELL NO. MW-3

LOCATION Keokuk, Iowa

INSTALLATION DATE 10-13-89

MONITORING WELL LOCATION _____



BENCH MARK _____

WHITNEY & ASSOCIATES
PEORIA, ILLINOIS

TELEPHONE
309 673-2121

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STEEL - BITUMINOUS CONCRETE
CONSTRUCTION MATERIALS
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SOILS AND GRAVEL SURVEYS
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DRILLING - CORING - TESTING

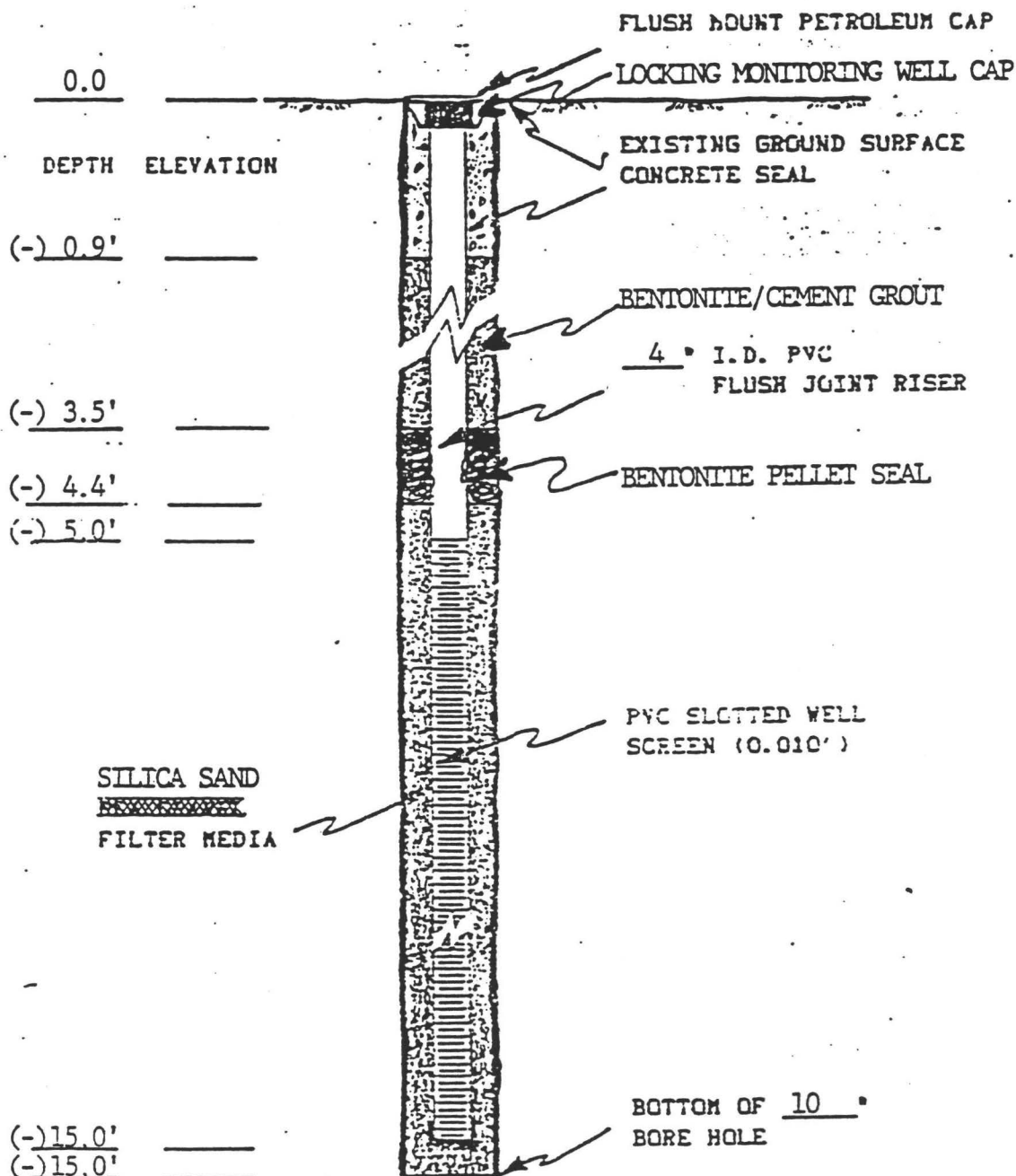
10-13-89

DATE

TYPICAL MONITORING WELL DIAGRAM

PROJECT Scheller Globe Corporation
LOCATION Keokuk, Iowa
MONITORING WELL LOCATION _____

MONITORING WELL NO. MW-4
INSTALLATION DATE 10-13-89



BENCH MARK _____

WHITNEY & ASSOCIATES
PEORIA, ILLINOIS